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ERRATA.

Tropical Agriculturist, Vol. CIII. No. 3, July to September, 1947, Issue :—

1. Page 174, line 23, for " Cleome tenella " *read* " Polanisia graveolens ".
2. Page 185, *insert* after Mukteswar in line 3.—" (Extracted from the Indian Journal *of Veterinary Science*, Vol. XVI., Part II., page 45, *et seq.*)".

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The

Tropical Agriculturist

JANUARY TO MARCH, 1948

EDITORIAL

SHIFTING CULTIVATION

THE forest dweller in the first stage of society lives by hunting and collecting such edible wild plants as he can find. A large advance is made when he reaches the stage of cultivating crops and rearing domesticated animals to serve him for food or power. The most primitive form of cultivation is to clear away the forest growth to make room for a cultivated crop and the man who reaches this stage, being necessarily without tools beyond the simplest, adopts the "Chena" method as the only one within his power. With axe, hoe and fire as his only tools he clears the jungle as far as he is able, sows his seeds and gathers one or two crops before secondary jungle growth and weeds make it impossible to continue on the same ground. He then moves to a new site, rotating the ground instead of rotating the crops. With the primitive means at his disposal the eradication of stumps and roots is impossible so that animal-drawn ploughs and harrows cannot be used. The chief factor in causing a move to a new site is undoubtedly the invasion of weeds, as Willis pointed out in 1914 and as is shown in the investigation reported by Joachim and Kandiah in this number.

The system of "Chena" cultivation is widespread throughout the tropics but as practised in Ceylon it differs in one respect from that commonly found in other parts of Asia. Throughout Indonesia, Malaya, Siam, Indo-china, Burma, Assam, and India, "Chena" cutting is scarcely ever found except in hill areas where the slope of the land does not permit the use of animal-drawn implements or where the people have not developed to the stage of keeping domesticated animals. We have never seen "chena" cultivation extensively practised on level or gently sloping land in Asia except in Ceylon. We can only conclude that it is not physically necessary that it should be so, neither is there any need for it on the grounds of fertility maintenance or erosion control, provided the rotational cropping which replaces it is done properly. There is no need for a long fallow, though only under the most intensive systems can a fallow be omitted.

"Chena" cultivation requires large areas of land, far more than the actual area under crops at any one time. So long as the population is not increasing the land rotation can go on but as soon as population rises a shortage of land develops and the proportion of landless men increases, with all the social ills which that engenders to follow. In Ceylon there is a land hunger in

some parts with holdings reduced to an uneconomic size while in other parts there is still excess of land permitting a shifting system of agriculture. This uneven population density magnifies the food problem since "Chena" cropping produces very little more than requisite for the chena cultivators' own needs while the tiny holdings in other parts yield little or no surplus.

There is a real and urgent necessity to change from shifting cultivation to fixed agriculture, to a recuperative system of farming which will maintain cultivation permanently on the same land. There is need to develop a symbiotic relationship between the farmer and the land and to escape from the parasitic attitude inherent in shifting cultivation.

In Ceylon there is no tradition of rotation agriculture on dry lands and there does not exist a peasant community who will readily adopt such a system of their own volition. In fact, the "Chena" cultivator cannot escape from the jungle because he lacks the means, financial and physical, of clearing the land sufficiently to permit the use of implements. Something has been done to work out systems of rotations suitable for the dry zones of Ceylon and at least one colonisation scheme (Kurundankulam) has given promising results. The report on this scheme by Jinendradasa in this number shows that there is no insuperable difficulty though it does indicate the need for further study of the agronomy of the dry zone. There is, however, need for further research into cropping practices and especially into the design of cheap, light implements suited to the draught animals available, these being an essential ingredient of rotational cropping, both for their traction power and as converters of plant waste into fertilizer. The proper management of the soil, both for erosion control and moisture conservation in areas of low rainfall or liable to droughts, has not been fully worked out.

This number of *The Tropical Agriculturist* is the first issue following the attainment of the Independence of Ceylon. It is appropriate to consider future possibilities in the agricultural development of the new Dominion.

The most outstanding fact is that Ceylon cannot feed her present population and that the burden of food purchases is likely to press heavily on the people unless internal production can be greatly increased. There are limits to the possible extensions of paddy cultivation but a much more distant limit to the development of rotational farming in the dry areas—though these are not nearly as dry as many countries which successfully raise crops. If it is said that this would entail an agricultural revolution, then why not ?. That kind of revolution would be worth while, though we would prefer to call it agricultural evolution.

SOIL FERTILITY STUDIES

2. THE EFFECT OF SHIFTING (CHENA) CULTIVATION AND SUBSEQUENT REGENERATION OF VEGETATION ON SOIL COMPOSITION AND STRUCTURE

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SUMMARY

INVESTIGATIONS were carried out over a number of years at various dry zone centres to determine :

(*a*) whether the adoption of the shifting (*chena*) system of cultivation in the tropics is necessitated by the reduction of the level of soil fertility by two or three successive seasons of cropping to such limits that further profitable cultivation is not feasible, and

(*b*) the rate of recuperation of the soil during the period of regrowth of the vegetation, in order to ascertain the minimum interval of rest required before the land can be utilized again for successful chena cultivation.

Two methods of approach were explored. On the one hand, existing areas of known chena history were studied ; on the other, investigations were made on virgin jungle areas cultivated under chena conditions and rested thereafter.

These investigations have indicated that while there are some losses of organic matter, nitrogen, and mineral nutrients as a result of chenaing land, these would occur under any system of rotational cropping on new jungle land and are not such as would render the land unsuitable for further profitable cultivation with a succession of annual crops. There are no appreciable adverse changes in soil structure as a result of chenaing land. The factors limiting the continuance of cultivation on these chena areas are : weed growth, insufficiently burnt stumps which begin to shoot up in a year or so, the lack and impracticability of tillage, and in some areas, soil erosion. In regard to the minimum interval between successive chenaings, it has to be pointed out that the chena crops depend for their successful growth on the

increased available nitrogen and ash resulting from the burn (the soil reserves being largely untapped) and the elimination of weed growth by the canopy of tree vegetation. This interval would thus be governed by the rate of growth of the latter, both in respect of height and density and would, therefore, vary in different districts.

INTRODUCTION

The practice of shifting cultivation is prevalent in most tropical countries, particularly those of the humid tropics, where it is known by different names such as *caingin* (in the Philippines), *tam rai* (in Siam), *ladang* (in the Netherlands Indies), *taungya* (in Burma), *shamba* (in Africa), *jhum* (in Assam) and *chena* (in Ceylon). The system is too well known to necessitate a detailed description in this paper, but in brief it consists in the cutting and burning of virgin or secondary jungle, the cultivation of a mixture of crops—cereals, legumes, vegetables and condiments—for, from one to at most three successive seasons, and the abandonment of the land thereafter for periods varying from 8 to 20 years during which time the vegetation regenerates itself. Two or three successive chenaings of the same land at insufficient intervals between them are reported to destroy the recuperative power of the jungle, and trees are succeeded by such grasses as *illuk* (*Imperata* spp) and in some areas, by *lantana* (*Lantana aculeata*) (1). The evils of shifting cultivation are the wasteful exploitation of forest land, the formation in due course of " wastes ", and the loss of soil through erosion in some areas. It is also not infrequently asserted that in chena cultivation soil fertility is reduced to such a level as a result of two or three successive seasons of cropping as to render further profitable cultivation not feasible. Hence the necessity for allowing the jungle to grow again until the initial soil fertility is restored. In order to ascertain whether there is any justification for this assertion, and if so, the minimum interval of the rest period required, trials were started about six years ago at various dry zone centres where chena cultivation is commonly practised.

EXPERIMENTAL

Two methods of approach were adopted. On the one hand investigations were carried out on two jungle areas cultivated under chena conditions and rested thereafter. On the other, existing areas of known chena history were studied. The details regarding the former are as follows :—

(i.) *Eriyagama.*—(N.C.P.) on the Anuradhapura—Kurunegala road about 12 miles from Anuradhapura. Vegetation—good jungle, soil—a deep red loam.

(ii.) *Rambawe.*—(N.C.P.) on the Anuradhapura—Jaffna road, about 10 miles from the former. Vegetation—medium jungle, soil—a grey brown, rather shallow loam.

The areas were sampled at the start of the trial before the jungle was cut, after cutting and burning, after the first and second crops respectively, and after 5 years of jungle regeneration. Soil samples were taken to 6 inches depth in every case, several samples being mixed together and a composite sample obtained.

Before the chena histories of the sites selected for the second series of investigations are detailed, it is necessary to explain certain terms used in

the Sinhalese districts of the North-Central Province where chena cultivation is common to denote types of land at various stages of recuperation after chenaing. These are as follows :—

Kanatte—an abandoned chena.
Lande—a 3-4 year old abandoned chena.
Hirilande—a 5-6 year old chena jungle.
Attanduwe—a medium jungle superior to ordinary jungle suitable for chena cultivation, and from 10-20 years old.
Mukulana—a high jungle.

The locations and characteristics of the sites examined are given below. In every instance soil samples were taken to the same depth (6 inches) from plots as near as possible to each other.

(1) *Rambawe* (N. C. P.), as already described. Four types of land were sampled under chena, lande, hirilande and attanduwe.

(2) *Eriyagama* (N. C. P.). Six types of land were sampled—chena, kanatte, lande, hirilande, attanduwe and mukulana.

(3) *Dambulla* (C. P.). Four types of land were studied—kanatte, hirilande, unburnt jungle and after burning.

(4) *Pailiagama* (near Maho, in the N. W. P.). Five areas were studied—medium jungle, under chena, kanatte, hirilande and attanduwe.

(5) *Kibissa* (near Sigiriya in C. P.). Five types of land were sampled—mukalana, under chena, kanatte, hirilande and attanduwe.

(6) *Ittiketiya* on the Anuradhapura—Trincomalee road. Five types of land were sampled—jungle, chena, kanatte, hirilande and attanduwe.

Simultaneously with these trials, studies were made for purposes of comparison, of the changes which a jungle soil at Pelwehera (Dambulla) Farm had undergone as a result of cultivation with rotation crops.

ANALYTICAL PROCEDURE

The soils in all cases were examined for nitrogen, carbon, replaceable bases and reaction by standard methods and, in some instances, for readily available phosphoric acid. Soil structure determinations were carried out by a water-sieving method, the minimum diameter size being 0·25 mm. The method adopted was as follows :—50 gm. of soil sieved through a 3 mm. sieve were placed in a 2 mm. sieve and allowed to soak in water overnight. The saturated soil was transferred to a 60-mesh sieve and the latter worked slowly up and down in a bucket of water, till the water was clear in the sieve. The material on the sieve was collected, dried and weighed, and the total crumb percentage determined. The " true " crumb value was obtained by placing the dry material on the same sieve, running water through it from a tap, and destroying the crumbs by hand. The material remaining on the sieve (particles>0·25 mm. diameter) was dried and weighed, the weight deducted from that of the crude crumbs and the true crumb percentage calculated.

RESULTS AND DISCUSSION

The results of analysis of the various soils are shown in Tables I. II. III. IV. and IV.A. These results will now be examined separately and collectively.

TABLE I

Changes in Soil Composition under the Chena System of Cultivation

	Eriyagama (N. C. P.)						Rambawa (N. C. P.).					
	Adjoining jungle.	Jungle before clearing.	After burning.	After 1st crop.	After 2nd crop.	After 5 years recuperation.	Adjoining jungle.	Jungle before clearing.	After burning.	After 1st crop.	After 2nd crop.	After 5 years recuperation.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	4·29	4·55	4·36	3·38	2·15	3·18	1·96	2·08	2·06	1·57	1·13	1·97
Loss on ignition	8·73	8·26	7·41	7·03	6·53	7·02	4·36	4·02	4·20	3·87	3·50	4·18
Organic matter	5·45	4·52	4·40	3·91	3·63	3·99	2·64	2·38	2·28	2·13	1·94	2·72
Carbon	3·15	2·62	2·55	2·27	2·15	2·31	1·54	1·38	1·32	1·23	1·13	1·54
Nitrogen	0·235	0·218	0·218	0·186	0·187	0·198	0·126	0·127	0·117	0·116	0·104	0·119
Total replaceable bases (m.e./100 gm. soil)	20·98	20·26	25·64	20·24	20·42	19·00	11·43	12·37	11·13	10·19	10·29	11·21
Readily available P_2O_5 (mgm./100 gm. soil)	1·73	1·06	4·42	2·13	3·00	1·68	4·84	2·00	5·13	4·63	4·41	3·94
Reaction pH	7·0	7·0	7·4	7·6	7·7	7·4	7·3	7·4	7·4	7·4	7·4	7·3

Table I. details the changes in composition undergone by the soil in two areas in the N. C. P. viz., at Eriyagama and Rambawe respectively, at various stages of the chena cycle and five years after the abandonment of the land. It will be noted that in both areas there are losses of organic matter and nitrogen as a result of burning, while the exchangeable base content does show an appreciable rise at one centre. This is evidently due to the absorption by the clay complex of the mineral nutrients from the ash as a result of favourable moisture conditions. Readily available phosphates also show an increase as a result of burning but fall with subsequent cultivation generally. The nitrogen, organic matter and base contents are further reduced by cropping at both centres, but while the fall in base content is very marked at Eriyagama, it is not appreciable at Rambawe. Resting the land for five years has improved the nitrogen and organic matter contents of both soils to some extent, but the increases are more marked in the case of the Rambawe soil. The exhangeable base content figures are conflicting. At Rambawe there is a slight rise and at Eriyagama a fall. There were indications that the Eriyagama land had been illicitly cleared in patches and this may account for the anomalous results obtained. It would, however, be reasonable to infer from these analyses that the loss of nutrients on chenaing land are not such as to render its further cultivation uneconomic. Five years of resting have produced some increases in the percentages of the important soil constituents but there were large reserves of these constituents in the soil even when the land was abandoned. Further, it has to be remembered that even under a system of rotational cropping, the cutting and burning of the jungle are normal operations, and unless the land is stumped immediately, a chena crop is always taken.

TABLE II

Pelwehare—Rotation Area

	Rotation area not composted. Per Cent.	Rotation area composted. Per Cent.	After burning. Per Cent.	Jungle area. Per Cent.
Moisture	2·85 ..	2·24 ..	1·95 ..	3·55
Loss on ignition	4·41 ..	5·18 ..	4·67 ..	6·00
Organic matter	3·14 ..	3·38 ..	3·58 ..	5·10
Carbon	1·82 ..	1·96 ..	2·08 ..	2·96
Nitrogen	0·104 ..	0·104 ..	0·111 ..	0·173
Total replaceable bases (m.e./100 gm.) ..	13·17 ..	13·01 ..	12·07 ..	14·21
Readily available P_2O_5 (mgm./100 gm.) ..	2·86 ..	3·71 ..	3·75 ..	1·55
Reaction pH	8·0 ..	8·0 ..	7·7 ..	7·8

In Table II. the results of analysis of soils of adjacent plots of jungle land brought under rotational cropping are shown. The plots had been stumped after the first chena crop of kurakkan (finger millet) and a crop of gingelly taken on the stumped land before the soil samples were drawn for analysis. One plot had received an application of 5 tons of compost per acre. It will be noted that the data confirm what has already been observed in regard to the losses of organic nutrients on burning the jungle and on subsequent cropping. The nutrient status of the soils at the time of sampling will be seen, however , to be no higher than that of the plots at Rambawe and Eriyagama (compare Table I.) at the time they were abandoned after chena cultivation.

TABLE III

Crumb Structure of Soils under Chena Cultivation. ($> \frac{1}{4}$ mm.)

State of regeneration.	Ittiketiya (N. C. P.). Per Cent.		Pailiagama (Maho N. W. P.) Per Cent.		Kibissa (Sigiriya C. P.). Per Cent.		Eriyagama (N. C. P.). Per Cent.		Rambawe (N. C. P). Per Cent.	
	Total.	True.	Total.	True.	Total.	True.	Total	True.	Total.	True.
(1) Jungle	79.4	37·6	86·0	31·0	82·6	44·2	83·8	52·0	68·4	43·2
(2) 10–12 year old chena ..	78·0	38·2	72·8	28·6	83·4	57·2				
(3) 8–9 year old chena ..					75·8	44·4				
(4) 5–6 year old chena ..	76·8	32·4	80·4	39·0	66·8	37·6				
(5) Abandoned chena ..	58·0	31·8	87·0	26·0	66·6	39·0	78·2	48·8	70·2	43·0
(6) Cultivated chena ..	59·0	34·4	78·0	30·0	83·2	46·0				
(7) After 5 years recuperation ..							82·8	49·8	69·6	44.0

A CHENA JUST ABANDONED AT PELWEHERA NEAR DAMBULLA. NOTE STUMP GROWTH AND WEED COVER. THE ORIGINAL FOREST IS IN THE BACKGROUND.

AN ABANDONED CHENA NEAR DAMBULLA. THE WEEDS ARE SO DENSE THAT THE CROP OF GINGELLY HAS MADE LITTLE HEADWAY.

The data obtained on the changes in soil structure during chena cultivation are shown in Table III. It will be observed here that there are no adverse effects on soil structure, expressed as percentages of total crumbs or true crumbs, as a result of chenaing forest land. The resting of the land for five years both at Eriyagama and Rambawe has brought about no improvements in the crumb structure of these soils.

Thus chena land on abandonment is both from the fertility and structural points of view, in much the same condition as any other land that is utilized for rotation cultivation. Confirmation of this finding is also furnished by reference to the data obtained for the other centres of trial. What then it may be asked are the reasons for the adoption of this system of cultivation? The answer is weed growth, which is beyond the capacity of the chena cultivator to tackle by hand and to control which, implements, were he able to obtain them, cannot be used owing to the presence of stumps on the land. Some of the latter would also by then have shooted up. The photographs accompanying this article illustrate these points clearly. Loss of soil by erosion may occur and in some instances might probably be severe. But the available data do clearly show that in the areas under trial this factor has not operated to such an extent as to cause marked reduction in soil fertility and necessitate the abandonment of the land.

[For Tables IV and IVA see page 10]

Tables IV and IVA above furnish data on the analytical composition of soils from blocks of land as nearly adjacent as possible to each other but with different chena histories. The soils of these blocks differ fairly appreciably among each other in character, topography, &c., and the data have therefore to be considered with this limitation. The data confirm generally what has been deduced from the first series of investigations already discussed, namely, that losses of soil nutrients occur when jungle land is cultivated under the chena system, but the nutrient status of the soils at abandonment is such that it can still produce a succession of annual crops with profit, provided proper cultivation is carried out and some manuring done. What they further indicate is that the chena cultivator does not make use of the reserves of plant food in the soil, these being largely untapped by reason of the method of cultivation he adopts, viz., sowing the seed broadcast and covering it by scraping the soil lightly on the surface. The chena crops depend therefore, for their successful growth on the ash produced from the burnt vegetation, and the increased available nitrogen which other workers (2,3) have demonstrated does result from the burn in shifting cultivation.

Tables I, IV and IVA also throw some light on the question of the minimum interval of rest required before an area which has been chenaed once can be uilized for the purpose again. If the criterion is that a soil must be rested for such a period that its intrinsic composition approaches that of the original jungle soil, them some of the data of these tables indicate that a period of 5 to 10 years would appear to be adequate. The figures for Rambawe in the North-Central Province, and for Kibissa in the Central Province give support to this conclusion. But, as has already been demonstrated, it is not loss of intrinsic soil fertility but rather weed and stump growth and occasionally soil erosion that have necessitated the adoption of the chena

TABLE IV

Composition of Soils in Varying Stages of Recuperation after Chena Cultivation

	Rambawe (N. C. P.).				Eriyagama (N. C. P.)						Dambulla (C. P.)			
	Present Chena.	3–4 year old chena Lande.	5–6 year old Hiri-lande	15–20 year old Attan-duwe.	Present Chena.	2 year old Kanatte.	3–4 year old Lande.	5–6 year old Hiri-lande.	10–15 year old Attan-duwe.	Mukulana jungle	Aban-doned chena Kanatte	5 year old chena Hiri-lande.	Jungle after burning	Jungle.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Moisture ..	3·33	2·92	2·95	3·15	5·32	3·83	4·23	4·06	4·56	6·18	3·14	3·61	3·15	2·89
Loss on ignition ..	4·65	4·27	5·86	4·85	6·45	4·59	4·95	4·88	5·53	9·09	5·04	5·49	5·50	4·15
Organic matter ..	2·29	2·13	1·97	3·83	4·49	2·52	3·18	2·75	2·55	6·42	4·97	5·00	4·48	6·04
Carbon ..	1·27	1·24	1·15	2·22	2·60	1·46	1·84	1·59	1·48	3·72	2·88	2·90	2·60	3·50
Nitrogen ..	0·127	0·105	0·113	0·129	0·203	0·133	0·143	0·138	0·136	0·300	0·142	0·151	0·147	0·121
Total replaceable bases (m.e./100 gm.)	14·09	12·79	10·34	12·39	20·52	11·34	13·48	12·63	14·44	21·02	15·34	14·96	17·97	14·21
Readily available P_2O_5 (mgm./100 gm.)	4·02	6·64	1·51	1·82	4·11	1·73	1·71	3·78	—	1·73	4·83	5·14	13·70	22·2
Reaction pH ..	7·7	7·7	7·5	7·4	7·9	7·9	7·5	6·7	7·4	7·9	7·6	7·3	7·4	7·3

TABLE IVa

Composition of Soils in Varying Stages of Recuperation after Chena Cultivation

	Pailiagama (Maho N.W. P.).					Kibissa (Sigiriya C. P.).					Ittiketiya (Anuradhapura N. C. P.).				
	Present Chena	Aban-doned chena Kanatte.	5 year old chena Hiri-lande.	10 year old chena Attan-duwe.	Jungle.	Present Chena.	Aban-doned chena Kanatte.	8–9 year old chena Hiri-lande.	18 year old chena Attan-duwe.	Mukulana jungle.	Present Chena.	Just aban-doned Kanatte.	5–6 years after chenaing Hiri-lande.	10–12 years after chenaing Attan-duwe.	Jungle.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Moisture ..	1·72	2·19	1·86	1·59	1·72	5·85	4·51	5·23	6·32	4·55	2·06	1·74	1·68	1·67	1·90
Organic matter ..	4·02	2·88	2·90	2·44	4·11	3·68	3·16	3·97	4·23	3·83	3·46	3·55	3·19	3·26	4·07
Carbon ..	2·34	1·67	1·68	1·42	2·39	2·14	1·84	2·31	2·46	2·23	2·01	2·06	1·85	1·89	2·36
Nitrogen ..	0·159	0·149	0·138	0·119	0·155	0·143	0·132	0·159	0·158	0·151	0·171	0·169	0·145	0·147	0·181
Total replaceable bases (m.e./100gm.)	7·32	5·98	7·74	7·83	6·46	14·92	11·08	14·46	14·08	13·12	11·17	11·83	9·33	10·58	12·14
Readily available P_2O_5 (mgm./100 gm.)	1·86	1·09	1·55	0·94	0·78	2·79	1·95	0·82	1·01	1·21	1·71	2·29	1·63	1·00	1·56
Reaction pH	7·0	7·1	6·9	6·9	6·9	7·3	7·1	7·0	7·1	7·1	6·9	7·4	6·7	6·6	6·7

system of cultivation. Weed growth will be naturally controlled by a sufficiently dense canopy of tree vegetation. The rate of growth of the latter, both in respect of height and density, will therefore determine the minimum rest period, and this would vary in different districts. Generally speaking from 8 to 10 years should be an adequate rest interval in most districts in Ceylon, both from the standpoint of weed control and the supply of a sufficiency of mineral nutrients from the vegetation.

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DELETERIOUS EFFECTS OF NITROGENOUS DRESSINGS WHEN USED ALONE ON BURMA PADDY SOILS

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IN most countries in Asia there have been many experiments on the effects of fertilizers on the yields of paddy so that it is generally possible to predict with reasonable certainty and exactitude what will be the immediate result of applying any of the common fertilizers to the important paddy areas, but there is a general lack of information on the long-term effects of fertilizers, both of residual effects from single dressings and of trends resulting from repeated applications. In attempting to discover the ultimate effects of artificials we find we are continually faced with a lack of adequate data because experiments have not been continued long enough, though sufficient has been revealed to cause us concern at the possibly bad effects which may follow nitrogenous dressings given alone. In western countries the effects of using such fertilizers as nitrate of soda and sulphate of ammonia alone are well known and the unscrupulous use of these by outgoing tenants or those having short tenancies, whereby a quick profit is realised at the expense of other soil nutrients, is only too common. In what follows the scantiness of the data is clearly recognised but we present these results because we feel there is a lack of understanding in parts of Asia of the ultimate results of applying nitrogen alone.

Tin (1941) examined the first eleven years results of the Permanent Manurial Experiment at Mandalay and found that sulphate of ammonia alone applied annually showed a negative trend which, however, just failed to reach significance at $P = 0{\cdot}05$. When superphosphate was applied alone there was a significant positive trend and when these two fertilizers were applied together the trends cancelled out leaving no discernable trend for the mixture. In an experiment in Lower Burma Rhind and Tin (1948–(1)) showed that there are long sustained residual effects from single dressings of bonemeal, super and basic slag, while in another experiment at Myaungmya (Lower Burma) Rhind and Tin (1948–(2)) found there was an undoubted negative trend when an ammonium phosphate fertilizer was applied yearly for eleven years. In all these cases there was a considerable increment over the unmanured plots, even to the end of the experiments, but these increments were declining yearly and at Myaungmya the decline had been so marked that cultivators had complained about it. That such effects are not confined to Burma is shown by Anandand, Krishnaswamy and Srinivasan (1943) who report that cultivators in Tanjore (South India) had complained of reduced yields following the year of application of sulphate of ammonia. Unfortunately their experiment, intended to test the cultivators' opinion, was laid down on plots which had previously received heavy dressings of bonemeal, and they used several strains of paddy during the course of the experiment, so that it is impossible to unravel their results and the conclusions drawn are

certainly open to doubt. The long-sustained residual effects from bonemeal would virtually make the nitrogen alone dressings amount to NP dressings. We quote the experiment more for the sake of the cultivators opinion, which we have come to trust to a large extent.

In seeking information on this matter we have turned to an old experiment conducted at Hmawbi Farm in Lower Burma (1913–14 to 1922–23). Such experiments of the pre-Fisherean era did not conform to modern experimental designs but there is no reason to suppose they gave false results because they were so designed as to be incapable of variance analysis. We are concerned with trends in responses over a period of time rather than with actual yields differences, so that in spite of the absence of replications and randomisation it is possible to fit regressions. In the experiment we re-examine the fertilizers were applied yearly for five years from 1913–14 to 1917–18 and in the succeeding five years residual effects were measured without further manuring. One variety was grown throughout as a single monsoon crop without rotation. The yields of paddy per plot are given in Table I., for the first five years when fertilizers were added annually.

TABLE I

Yields of paddy in lb. per plot at Hmawbi Farm
Fertilizers applied annually. Plots. 0·09 acre

Fertilizer in lb. per acre.	1913–14.	1914–15.	1915–16.	1916–17.	1917–18.
Bonemeal at 20 lb. P_2O_5	174	172	182	120	242
Super at 20 lb. P_2O_5	166	177	195	159	255
Sodium nitrate at 30 lb. N	148	135	120	62	115
Sodium nitrate at 30 lb. N as a top dressing	165	189	184	62	136
Nitrolim at 30 lb. N	199	170	173	84·5	127
Ammonium sulphate at 30 lb. N	205	231	217	114·5	166
Ammonium sulphate at 30 lb. N plus super at 20 lb. P_2O_5 plus sulphate of potash at 20 lb. K_2O	184	209	92	210	246
Sulphate of potash at 20 lb. K_2O	176	149	143	115	155
Control (unmanured)	142	163·5	136	94·2	184·6

Liner regressions are fitted to the paired differences of each treatment and control to ascertain the relationship between the effect of the fertilizer and time. In Table II. are given the mean percentage increases over unmanured with the values of *t*, *b* and the S. E. of *b*.

TABLE II

Values of t, b and the S. E. of b. with the percentage differences from the control for the total plot yields of Table I

Treatments.	Per Cent difference from Control.	*t*. ($n = 4$).	*b*.
Bonemeal	23·53	4·0283*	6·79 ± 5·64
Superphosphate	32·17	4·0215*	14·41 ± 4·40*
Sodium nitrate	−19·48	2·2730	− 15·49 ± 4·65*
Sodium nitrate top dressing	2·18	0·1699	− 19·09 ± 10·31
Nitrolim	4·61	0·3351	− 24·54 ± 4·20*
Ammonium sulphate	29·60	2·3204	− 21·04 ± 8·81
Ammonium sulphate + super + potash	30·64	1·7176	10·90 ± 20·02
Potassium sulphate	0·51	0·0634	− 6·97 ± 8·64

Value of t at P = 0·05 = 2·776. * = Significant.

Sulphate of ammonia has given a high positive response which we accept as real though it fails to reach significance at the conventional five

percent level. Nitrolim and nitrate of soda as a top dressing gave insignificant positive responses, while nitrate of soda before transplanting caused a considerable negative effect, though not quite reliable.

As between the nitrogenous manures applied alone it appears that it is quality which is most important and that the ammonium ion is the most suitable form in which to apply it, as has been shown repeatedly by many experiments. Both phosphatics gave large significant responses and there appears to be little or no advantage in combining these with nitrogen.

Considering the trends as shown by the regression coefficients it is seen that phosphates have given positive responses whereas with nitrogenous fertilizers and potash the trends are all negative. A consistent and highly significant decline in yields has followed repeated applications of nitrolim and nitrate of soda before transplanting, the loss in yield per year amounting to 272 lb. and 172 lb. of paddy per acre respectively. Sulphate of ammonia likewise showed a decline amounting to 212 lb. of paddy per acre but the regression coefficient just fails to reach significance at $P = 0{\cdot}05$. Repeated applications of ammonium sulphate continued to give increases over the unmanured throughout the first five years of the experiment and this conforms to general experience, but these increases were continually declining. The same effect appeared in the Mandalay experiment (Tin, *l. c.*). In practical farming this would mean that the cultivator would get a smaller and smaller return for the fertilizer applied. How far this decline might ultimately go we can only conjecture from an extension of the regressions. It is known that the barely significant negative trend reported by Tin at the end of 11 years had become decidedly significant by the 15th year. Superphosphate used alone showed a significant positive trend but when combined with ammonium sulphate the trend, though still positive, became quite insignificant, again agreeing with the Mandalay results.

The results of this Hmawbi experiment, so similar to those obtained on the very different soils of Mandalay, cannot be neglected. In our view they show that the application of ammonium sulphate alone cannot be continued indefinitely without soon reaching a point where the increase will become unprofitable, if not even worse and an actual depression result.

We now turn to consideration of the residual responses obtained from the same experiment when manuring was stopped after the fifth year. The yields of the five residual years (following five in which the fertilizers were applied annually) and the calculated statistics are given in Table III. and IV.

TABLE III

Yields of paddy in lb. per plot at Hmawbi Farm. Residual years without further fertilizing. Same plots as in Table I

Treatments.	1918–19.	1919–20.	1920–21.	1921–22.	1922–23.
Bonemeal ..	.. 192	.. 168	.. 135	.. 135	.. 71
Superphosphate ..	.. 195	.. 146	.. 124	.. 141	.. 132
Sodium nitrate ..	.. 133	.. 61	.. 72	.. 96	.. 71
Sodium nitrate top dressing	.. 141	.. 74	.. 87	.. 100	.. 79
Nitrolim ..	.. 144	.. 71	.. 78	.. 96	.. 135
Ammonium sulphate ..	.. 170	.. 77	.. 79	.. 112	.. 92
Ammonium sulphate + super + potash	192	.. 145	.. 149	.. 126	.. 140
Potassium sulphate ..	.. 164	.. 119	.. 87	.. 118	.. 110
Control ..	.. 190·4	.. 107·0	.. 137·8	.. 129·9*	.. 122·0

* The yield of the control in this year was missing from the records and the figure given is estimated by taking the mean of the yields of the third and fifth years.

TABLE IV

Values of t, b and the S. D. of b with the percentage difference from the control for the total plot yields of Table III

Treatment.	Per Cent. difference from Control.	t. ($n = 4$).	b.
Bonemeal	.. 2·023	.. 0·1564	.. − 16·1 ± 11·14
Superphosphate ..	.. 7·408	.. 1·2007	.. − 0·3 ± 6·68
Sodium nitrate ..	..−36·84	.. 8·6901*	.. 2·19 ± 4·59
Sodium nitrate top dressing	..−30·00	.. 9·7493*	.. 1·59 ± 3·33
Nitrolim	..−23·73	.. 2·6542	.. 12·09 ± 7·21
Ammonium sulphate ..	..−22·86	.. 4·3212*	.. − 0·71 ± 5·93
Ammonium sulphate + super + potash	.. 9·445	.. 1·7756	.. − 0·91 ± 5·95
Potassium sulphate ..	..−12·97	.. 1·7385	.. 0·49 ± 8·40

* = Significant.

In considering these results it is necessary to remember that a negative residual trend results when there has been a positive residual response which is dying away, that is, the residual response is decreasing. Conversely a positive trend, following a decline in yield in the years of application would indicate that a recovery from the depression was occurring.

Both the phosphate fertilizers and the NP gave higher yields than the controls, though insignificant at P = 0·05. Nitrogen alone showed large depressions in yields, as did potash also, and these were highly significant in all cases except Nitrolim, which was just below the 5 per cent level, and potash. The regressions are unreliable but in all cases except ammonium sulphate they suggest that a recovery was slowly taking place in the nitrogen-treated plots and that responses were declining in those plots receiving phosphates alone. This last would be expected.

With ammonium sulphate alone there was, therefore, a series of declining increments over the unmanured so long as the annual applications were maintained, followed by a series of years of depression lasting an undiscovered time. In this present experiment the losses from ammonium sulphate in the second five years when no fertilizer was applied nearly balanced the gains of the first five years, the overall increase for the ten years being only 55 lb. or 3·2 per cent. and the statistics suggest that another two years residuals would have converted in into an absolute loss. It is only when phosphorus is added that the overall yields for ten years show worth-while gains.

Had this been an isolated case we would have neglected it, but unfortunately it fits in with some other experiments and actual growers experiences. It amounts to this: if ammonium sulphate alone is applied there will be an immediate increase but that will be lost by depressions in succeeding years; if it is tried by repeated applications to keep the yields up, the responses will gradually decline and the ultimate depression will absorb the gains of the earlier years.

The case of phosphates applied alone is quite the reverse. As we have shown in papers already quoted basic slag, super and bonemeal all build up fertility and give large and prolonged residuals.

We record our unfavourable result with nitrogen dressings alone on somewhat slender data but suitable experiments for regression analysis are scarce. It agrees with field experience. It has occurred on widely different paddy soils; on heavy solonchak clay and rather sandy lateritic alluviums, on alkaline (pH-8·0) and acid (pH-6·1) soils, under high monsoon rainfall and under irrigation. The experiments never went as far as we now realise is

essential for a full understanding of these effects. It is our view that the use of sulphate of ammonia alone will create a nutritional unbalance in the soil such as may prove disastrous in the long run, and, as far as the paddy crop in Burma is concerned, we record our emphatic disapproval of sulphate of ammonia if used without at least the addition of phosphates.

It is clear that there is need for much more information about the effects of artificials on tropical soils under systems of monoculture with high rainfall or irrigation giving swamp conditions. Undesirable trends undoubtedly can arise from causes about which we refrain from speculating but which we think can only be discovered by a thorough study of the nutritional unbalance which is certainly common, and we feel that it is by long-sustained field trials rather than under the artificial conditions of pot culture experiments that the solution should be sought. The time has come for fewer trials of the " spot " variety and for more long-term experiments which will permit trends to be discovered by regression analysis. The system of monoculture under a single monsoon, as in Burma paddy lands, offers specially favourable conditions where such experiments can be done without the complications of double cropping, rotations and fallows. We emphasise again the importance of choosing experimental plots which have not had previous dressings of phosphates because of the often very long residual responses which these give and the fact that when nitrogen dressings are combined with phosphate the opposite trends of the two fertilizers tend to cancel each other. We have estimated that phosphate residuals may last as long as 17 years at levels high enough to vitiate subsequent trials.

SUMMARY

1. Concern is expressed at the possible deleterious effects of nitrogenous artificials used alone on tropical paddy soils under a system of monoculture.

2. The data of an experiment in which fertilizers were applied annually for five years and then residual (unmanured) yields were measured for a further five years are examined by fitting linear regressions.

3. Phosphates alone showed large increases with positive trends when repeatedly applied. They showed residual effects declining with time.

4. Nitrogen alone only gave significant increases in the form of ammonium sulphate but these increases declined yearly during the first five years and showed a significant depression in the succeeding five years when no fertilizer was applied.

5. Dressings of ammonium sulphate result in a catch-penny profit in the beginning but ultimately may prove expensive. Strong disapprova of ammonium sulphate used alone as a fertilizer for paddy in Burma is recorded.

6. A plea is made for more long-term experiments, well designed and not complicated by phosphatic residuals from previous experiments, to elucidate the full effects of nitrogenous artificials in the field.

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SOIL FERTILITY STUDIES

THE FIXATION AND AVAILABILITY OF PHOSPHATES IN SOME CEYLON SOILS

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SUMMARY

ELEVEN soils belonging to the major soil groups of Ceylon were studied in respect of: (1) the various forms of phosphorus present in them (2) their power to fix added phosphates.

Soil phosphorus was fractionated into (*a*) readily available (*b*) alkali soluble inorganic (*c*) alkali soluble organic (*d*) acid soluble and (*e*) insoluble portions.

Most of these soils are acid in reaction and very low in readily available phosphoric acid. The neutral and slightly alkaline soils from Hingurakgoda and Jaffna respectively, have fair amounts. The reaction of a soil seems to control the amount present.

The acid soils are relatively high in both the alkali soluble fractions (b & c). An inverse relationship exists generally between the pH of these soils and their percentages of these fractions.

Iron and aluminium phosphates are regarded as the main constituents of the alkali soluble inorganic fraction. As the normal phosphates are available to plants, while other forms are not, the extent of the immediate availability of this fraction would depend on the relative amounts of these two forms.

The organic fraction, though not directly available to plants, is considered to be, on decomposition, a valuable source of phosphorus. The organic soils from Bopatalawa and Matara and the paddy soil from Gampola are relatively rich in the organic fraction. Liming the soils helps its mineralization.

Acid soluble phosphorus is found to be highest in the Jaffna and Nalanda soils of limestone origin and lowest in the Bopatalawa soil. A positive correlation exists between the reaction of a soil and the percentage of this fraction.

The Nalanda soil has the highest amount of insoluble phosphorus.

The soils studied vary very greatly in their power to fix added phosphorus. The laterite Bopatalawa soil shows the highest fixing power and the non-lateritic Jaffna soil the lowest. Sub-soils fix phosphates to a greater extent than their surface soils. Fixing power of organic matter seems to be low.

Practical suggestions to increase availability of soil phosphorus and to decrease fixation are made. Phosphate fertilization is discussed.

INTRODUCTION

Of the three major plant nutrients supplied to soils in the form of manure, it is phosphoric acid that is least accounted for in the crop. In a manurial experiment carried out at Peradeniya (1) where ammonium phosphate was applied to paddy at the rate of 96 lb. per acre, it was observed that the nitrogen added was fully recovered in the crop, but the quantity of phosphoric acid removed was only 20–25 per cent. This low return of phosphoric acid is due partly to the fact that a portion of what was applied was temporarily fixed in a form unavailable to plants. It should be noted here that the term fixation in agricultural usage is used to connote two contrasting ideas. When it refers to nitrogen it denotes a change from the unavailable (elemental) to the available state (nitrogenous compounds), while in the case of phosphoric acid it refers to a change from the available to the unavailable or difficultly available form. The phenomenon of phosphate fixation has been investigated by a number of workers. It is not proposed to review in detail the voluminous literature on the subject, but factors relevant to this investigation will be discussed under each section. Mention may, however, be made that the consensus of opinion is that fixation depends as summarised by Davis (2) on (*a*) the nature and content of the soluble and exchangeable basis. (*b*) the composition of the colloidal fraction, *i.e.*, its silica/sesquioxide molecular ratio, (*c*) the degree of saturation of the reactive components with phosphorus compounds, (*d*) the hydrogen-ion concentration of the soil, (*e*) the content and nature of the organic matter and (*f*) the physical condition which affect chemical equilibria including temperature, time and moisture content.

In Ceylon occurs a wide variety of soils, which vary greatly in texture, organic matter, reaction, and the nature of the clay. It was therefore considered desirable to study (1) the distribution of the different forms of phosphorus compounds in eleven of the soils belonging to the major soil groups of Ceylon and (2) the power of fixing added phosphates of these soils.

SECTION (I)

Distribution of the different Forms of Phosphorus in Soils

Phosphorus is known to exist in various forms in soils and Dean (3) was the first to attempt to fractionate them. Ghani (4) later improved on the method and divided the soil phosphorus into five fractions according to their chemical composition and availability to crops.

(1) Readily available—the three forms of calcium phosphates, soluble in 0·002 N. H_2SO_4 (pH 3·0).

(2) Moderately available—phosphates of aluminium and iron, the inorganic fraction soluble in 0·25 N. NaOH.

(3) Available on further decomposition only—organic phosphates such as phytin, lecithin, nucleic acid, &c.—the organic fraction soluble in 0.25N · NaOH.

(4) Probably unavailable—apatite, the fraction soluble in 2N. H_2SO_4.

(5) Definitely unavailable—the insoluble portion forming an integral part of the clay itself. The difference between the total phosphorus and the sum of the above four fractions.

Information was secured on the amount of each of these fractions present in the eleven soils, as the knowledge thus gained would throw light on the degree of availability of phosphoric acid to crops in these soils and also give an idea as to how best they should be treated, so as to enhance their nutrient status from the point of view of phosphoric acid. The characteristic features of the soils studied are given in Table I.

TABLE I

Important Soil Characteristics

	Location	Depth of Sample	Reaction PH	Organic Matter Per cent.	Silica/ Sesquioxide (molecular)	Nature of Clay
1.	Bopatalawa	0–12″	4·39	9·76	0·92	Laterite
2.	,,	12–24″	4·39	—	—	,,
3.	Massena	0–12″	4·30	4·18	1·26	,,
4.	,,	12–24″	4·32	—	—	,,
5.	Ambepussa	0–12″	4·96	1·78	1·40	Lateritic
6.	,,	12–24″	4·96	—	—	,,
7.	Gampola	0–9″	5·26	5·84	1·18	,,
8.	Peradeniya	0–9″	5·04	3·06	1·21	,,
9.	Nalanda	0–9″	6·99	2·07	1·69	Non-lateritic
10.	Bathalagoda	0–9″	5·30	3·16	1·58	,,
11.	Maha-Illupalama	0–9″	6·83	2·32	1·61	,,
12.	Matara	0–9″	5·03	12·46	1·34	Lateritic
13.	Hingurakgoda	0–9″	7·03	3·08	2·98	Non-lateritic
14.	,,	0–18″	7·18	—	—	,,
15.	Jaffna	0–9″	8·03	0·87	2·01	,,

EXPERIMENTAL

The method of extracting and determining the various fractions adopted by Ghani (4) was used in these studies with some modifications. In certain preliminary trials conducted, it was observed that Chamberland filter candle used by Ghani tended to absorb phosphates from solution in the process of filtration and that the slower the rate of filtration, the greater was the amount of absorption. The extraction was therefore carried out by treating 5 gm. soil, pretreated with 0·5N acetic acid to remove the exchangeable bases, with 200 cc. of ·25N sodium hydroxide for a period of six hours in a water bath at 70°C. In determining the readily available portion, 0·002N. sulphuric acid was used instead of 0·5N. acetic acid, as the former was the conventional reagent (Troug) used for extracting this form of phosphorus. Besides, the filtrate even with the organic soils, was quite clear for colorimetric determinations made in a Lovibond tintometer, which was not the case when acetic acid was used. Standard analytical methods were used in the other determinations. The results obtained are shown in Table II. To facilitate comparison the results are also worked out as percentages of the total phosphoric acid and shown in italics.

TABLE II

Fractions of Soil Phosphorus (Mgm P_2O_5 per 100 Gm Soil)

Figures in Italics refer to Percentages of the Total

Location and Depth of Sample	Massena 0–12″	Bopata-lawa 02–12″	Bopata-lawa 12–24″	Ambe-pussa 0–12″	Matara 0–9″	Pera-deniya 0–9″	Gampola 0–9″	Batala-goda 0–9″	Maha-Illupalama 0–9″	Nalanda 0–9″	Hingurak-goda 0–9″	Jaffna 0–9″
Reaction pH	4·30	4·39	4·39	4.96	5·03	5·04	5·26	5·30	6·83	6·99	7·05	8·03
Readily available	1·3	1·1	1·0	1.6	4·1	5·4	7·0	1·8	3·3	4·9	11·8	28·8
	·7	*·4*	*·5*	*1.0*	*2·3*	*2·1*	*2·4*	*1·8*	*2·0*	*1·8*	*7·0*	*8·1*
Alkali Sol. Inorganic	44·0	93·0	78·0	47.0	63·0	86·0	105	39·0	39·0	72·0	45·0	95
	25·0	*36·9*	*39·2*	*27.9*	*34·8*	*33·3*	*35·9*	*38·2*	*23·1*	*26·3*	*26·9*	*26·7*
Alkali Sol. Organic	68·0	112·0	60·0	48.0	73·0	111·0	120·0	36·0	50·0	60·0	42·0	80
	38·6	*44·4*	*31·2*	*29.6*	*40·3*	*43·0*	*41·1*	*35·4*	*29·8*	*21·9*	*25·6*	*22·7*
Acid Sol. Inorganic	21·0	13·0	18·0	23.0	17·0	22·0	27·0	14·0	38·0	72·0	42·0	98·0
	11·9	*5·2*	*9·2*	*13.9*	*9·4*	*8·5*	*9·2*	*13·7*	*22·5*	*26·3*	*25·0*	*27·5*
Insoluble	42·0	33·0	39·0	45.0	24·0	34·0	33·0	11·0	39·0	66·0	27·0	53·0
	23·9	13·1	19·9	27.3	13·2	13·2	11·3	10·8	23·1	24·1	16·1	14·8
Total	176·0	255·0	196·0	165.0	181·0	258·0	292·0	102·0	169·0	274·0	168·0	355·0

Readily Available Phosphorus.—This fraction is low except in the case of the Hingurakgoda and Jaffna soils, which are neutral and slightly alkaline respectively. Brown (5) points out that the greatest amount of available phosphoric acid is present at a pH of 7·9, as at this reaction the solubility of iron and aluminium is lowest and there is very little free calcium carbonate present. It will be observed that with a rise in pH the amount of readily available phosphoric acid also, as is to be expected, shows an increase.

Alkali Soluble Inorganic Phosphorus.—Though this fraction is second in magnitude in most of these soils, it is the most important one from the point of fixation, as added phosphates are likely to be converted principally into this form and the plants have to draw their requirements from this store. It varies in quantity in these soils, from 39·0 mgm percent in the Bathalagoda soil to 95 mgm. per cent. in the Jaffna soil. If the percentage figures are compared it will be observed that the highest percentage is present in the Bopatalawa soil and the lowest in the neutral Maha-Illupalama soil. In general there is a correlation between the pH of the soils and the amount of this fraction.

The average alkali soluble inorganic content, made up principally of iron and aluminium phosphates, is about 51 mgm. per 100 gm. soil, which works out to over 1,000 lb. per acre of soil to a depth of 6 inches. Ford (6) points out that ferric and aluminium phosphates are quite readily available to plants. Marais (7) also holds the view that mineral phosphates of aluminium and iron are valuable sources of phosphorus to plants. Hance (8) working under Hawaiian conditions asserts that plants like sugar cane utilize tri-calcium, ferric or aluminium phosphates. Troug (9) goes further when he reports that " nine out of ten plants gave better growth on aluminium phosphate than on calcium phosphate and that six made better growth on ferric phosphate than on calcium phosphate ". If the whole amount of this fraction exists as the normal phosphates of aluminium and iron, there then should be a sufficiency of this constituent to meet the requirements of most plants. In actual practice, however, when soluble phosphates are applied to most soils, they become unavailable to plants. It must therefore be conceded that the soluble phosphates applied form compounds other than the normal phosphates of iron and aluminium and these the plants cannot utilize. Heck (10) states that the nature of the iron and aluminium phosphates formed would depend upon the state of hydration of their oxides. If the oxide of iron is fully hydrated, only then will the normal iron phosphate ($FePO_4$) be formed, but as tri-hydrated iron oxide is unstable, there is not much possibility of this reaction taking place. Ford (6) quotes Leith & Mead to show that goethite (limonite) $Fe_2O_3 \cdot H_2O$ and bauxite $Al_2O \cdot_3 . XH_2O$ appear as products of laterization. He further demonstrates that the phosphatic compounds formed with goethite are as insoluble as dufrenite $Fe_2O_3 . H_3PO_4$. Heck (10) is of opinion that compounds even more insoluble than dufrenite may be formed.

From the foregoing, it has to be inferred that iron and aluminium compounds of very low solubility are formed when phosphatic fertilizers are applied to soils, particularly of the lateritic and laterite types. As these compounds are also soluble in 0·25N. NaOH, the extent of the immediate availability of this fraction would depend on the proportions in which these two types of compounds are present.

Alkali Soluble Organic Phosphorus.—This constitutes the largest fraction in most of these soils. It varies in quantity much more widely than the inorganic portion, the lowest amount being found in the Ambepussa soil and the highest in the Gampola soil. A study of the percentage figures would indicate that an inverse relationship exists between the reaction of a soil and its content of alkali soluble organic phosphates, the higher amounts being found in the more acid soils. Organic matter also seems to exert its influence on the quantity of this fraction as indicated by the relatively high contents of the humic Bopatalawa and Matara soils and the paddy soil of Gampola. These may be the residual products of plant origin or synthesised products of bacterial action. Shorey (11) Wrenshall *et al.* (12) Yoshida (13) and Bottomley (14) have shown that organic phosphates exist in soil as lecithin in small quantities and as nucleic acid and phytin in relatively large amounts. Rogers and his associates, (15) claim to have established that corn and tomato absorb directly from nutrient solutions both phytin and lecithin, but many workers hold the view that these organic phosphates should first be mineralized to be taken up by plants. Pearson *et al.* (16) have demonstrated that the decomposition of phytin is slow, but that of nucleic acid is fast. Addition of lime leads to the rapid mineralization of phytin. The organic phosphates present in the local soils may therefore prove to be a valuable source of phosphorus to plants, if they are first mineralized by liming.

Acid Soluble Phosphorus.—It has been shown by Ghani and Aleem (17) that this fraction represents the apatite phosphates present. In the soils studied the highest amounts of this fraction are found in the soils of limestone origin from Jaffna and Nalanda, viz., 72 and 98 mgm. per cent. and the lowest in the acid soil of Bopatalawa where it is only 13·0 mgm. per cent. A comparison of the percentage figures would indicate that there is generally a rise in this fraction with an increase in the pH of the soils.

In the calcareous soils, the relatively high amount may be due to the formation of the very slightly soluble carbonate apatite, $Ca_3(PO_4)_2\ CaCO_3$.

Insoluble Phosphorus.—This fraction which is considered unavailable constitutes what remains in the soil after the alternate acid and alkali extractions. Here again the quantities are highest in the calcareous soils of Nalanda and Jaffna. Reaction seems to bear no relationship to the amounts present in the various soils.

SECTION (II)

Fixing Power of Soils for Phosphates

In this investigation the eleven soils referred to previously and the sub-soils of three of them were included. The method outlined by Hibbard (18) was adopted but instead of sodium phosphate, mono-calcium phosphate was used. The fixing capacity of a soil was reckoned to be, as defined by Hibbard, the milligrams of phosphoric acid required to be added to a kilogram of soil to give a concentration of 1 p.p.m. in the extract. Though phosphate fixation is considered to be a time reaction nevertheless over ninety per cent. of the fixation takes place in the first hour. The results obtained are given in Table III.

TABLE III

Phosphate Fixing Power of Soils

Soil	Cwt./per acre as super	Mgm. P_2O_5 added	Mgm. P_2O_5 remaining in solution	Fixation	Fixing Power Mgm. P_2O_5 per 100 gm. soil
		Per cent.	Per cent.	Per cent.	
Bopatalawa 0–12″	1680	50	0·012	99·9	690
	2016	60	0·060	99·9	
	2352	70	0·101	99·9	
Bopatalawa 12–24″	2016	60	0·016	99·9	770
	2350	70	0·062	99·9	
	2688	80	0·120	99·8	
Massena 0–12″	1344	40	nil	100	670
	2016	60	0·030	99·9	
	2352	70	0·139	99·8	
Massena 12–24″	1680	50	0·039	99·9	750
	2352	70	0·076	99·8	
	2688	80	0·128	99·7	
Ambepussa 0–12″	504	15	0·056	99·6	200
	672	20	0·100	99·5	
	1008	30	0·169	99·4	
Ambepussa 12–24″	672	20	0·024	99·7	390
	1008	30	0·046	99·7	
	1344	40	0·104	99·6	
Gampola 0–9″	672	20	nil	100	410
	1344	40	0·066	99·8	
	1312	45	0·206	99·5	
Peradeniya 0–9″	336	10	0·028	99·4	210
	672	20	0·038	99·3	
	1008	30	0·114	98·8	
Nalanda 0–9″	336	10	0·036	99·6	160
	504	15	0·099	99·3	
	672	20	0·108	99·0	
Bathalagoda 0–9″	168	5	nil	100	95
	235	7	0·046	99·3	
	336	10	0·102	98·9	
Maha-Illupalama 0–9″	168	5	0·038	99·2	71
	235	7	0·090	98·7	
	336	8	0·151	98·1	
Matara 0–9″	67	2	0·016	99·0	53
	168	5	0·058	98·8	
	235	7	0·356	94·7	
Hingurakgoda 0–9″	33	1	0·098	90·2	11
	67	2	0·192	90·3	
Jaffna 0–9″	16	0·5	0·067	86·6	7
	33	1	0·15	85·0	

RESULTS OF DISCUSSION

The data indicate that the soils vary greatly in their fixing power, the highest fixation being in the acid Bopatalawa soil and the lowest in the slightly alkaline Jaffna soil. Others showing comparatively high fixation are the Massena and Ambepussa soils. It will be observed that the sub-soils have higher fixation power than their corresponding surface soils. The high fixing soils besides being acid in reaction have clays of the laterite or lateritic type, while those showing low fixation are neutral in reaction and their clays are non-lateritic. It would therefore be seen that fixation is governed by

the nature of the clay and/or the reaction of the soil. Beater (19) however points out that the effect of pH may not be looked upon as a dominant factor, as a large excess of active iron and aluminium are believed to overshadow its influence on the products of chemical action. Doughty (20) had established that natural or synthetic humus does not fix phosphorus. Fraps and Hamer (21) consider that in most cases fixation by organic matter is rather small. Since it is observed in this investigation that the surface soils have a lower fixation than the corresponding sub-soils and the acid, humic Matara soil also shows a comparatively low fixing power, our results would appear to confirm the view that organic matter plays only a minor role in fixation.

GENERAL DISCUSSION

There is diversity of opinion among investigators as regards the mechanism of fixation. While some consider it a purely chemical action, others regard it to be of a physico-chemical nature. Whatever the mode of fixation may be, there is general agreement that compounds of iron and aluminium, particularly those in the laterite and lateritic soils react avidly with added phosphates making them unavailable. Romine and Metzger (22) had demonstrated that fixation was low, when the sesquioxides were extracted from soils by treating them with dilute acids. The works of Kelly and Medgley (23) and that of Fraps (24) bear this out. Bear and Toth hold the view that under conditions of low pH, soils with low silica/sesquioxide ratios fixed large amounts of phosphorus and that the reverse was true when the pH was high. The results reported herein indicate that the acid soils with low silica/sesquioxide ratios fix considerable amounts of added phosphates. Under the condition of this investigation, the main fixation products can only be the phosphates of iron and aluminium and the question of their availability has already been discussed.

The problem of the agriculturist is therefore to treat the soil by suitable means so as to release the phosphorus present in it and to minimise the fixation of added phosphates. The evidence in literature clearly indicates that preliming the soil reduces fixation very materially. It has also been shown that liming promotes the mineralization of the phytin present in the soil. There is however difference of opinion as to how far liming would be able to release phosphoric acid from the insoluble inorganic phosphates in soil. Holman (25) has given instances of highly laterised soils in New South Wales, in which no soluble phosphoric acid was released over a range of pH 3–8 and concluded that liming would not have the effect of making phosphates in them available. Cook (26) on the other hand had demonstrated that liming soils ranging in pH from 4·83 to 6·30 had increased the availability of soil phosphates significantly in seven out of ten soils and slightly in two. Bear and Toth (27) held the view that absorbed phosphates in soils may be colloid-bound or saloid bound. When colloid-bound, they could be displaced by hydroxyl, silicate or humate and when saloid bound by chloride, suplhate, citrate, tartrate, &c., Mattson (28) in dealing with the displacing power of anions placed the following in their descending order thus: humate, phosphates, silicate. According to Marais (7) the effect of lime on the basic aluminium phosphate is different to that on the corresponding iron compound. When the former hydrolyses, the aluminium hydroxide can combine with calcium to form the insoluble calcium aluminate releasing phosphoric acid but no such

reaction takes place between calcium and iron hydroxide. Liming could therefore set free the phosphoric acid from aluminium phosphate but not from basic iron phosphates.

In view of the variation in the nature of the clays, reaction and fixing power of Ceylon soils, the importance of treating the different types differently will be readily understood. In the matter of phosphatic fertilization, the nature of the fertilizer, its amount, placement and time of application should receive consideration. From the results outlined herein, it is clear that rapid fixation of considerably high amounts of added phosphates takes place in the acid soils. It will therefore be seen that the application of soluble phosphatic fertilizers will not have any greater benefit on them than that of insoluble phospahtes. At Rothamstead it has been found that mineral phosphates are as good on acid soils as super. Vageler (29) advocates the application of larger amounts of cheap insoluble fertilizers in preference to smaller quantities of the costly soluble ones. Neutral or slightly alkaline soils on the other hand fix much less phosphorus than the acid soils. Soluble phosphates such as super should therefore be preferred to insoluble phosphates, the availability of which in these soils is very limited. According to Marais (7) Prainishinikov divided phosphatic fertilizers into two classes : one consisting of tricalcium phosphate, bone meal, phosphorite, &c., whose availability will be reduced by lime and the other made up of mono and di-calcium phosphates, Thomas slag, mono-potassium phosphate and iron and aluminium phosphates, &c., the availability of which is either unaffected or increased by lime.

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ROTATIONAL FARMING SCHEME, KURUNDANKULAMA, NORTH-CENTRAL PROVINCE

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OBJECTS OF THE SCHEME

A DRY farming experiment was started by the Department of Agriculture in 1938 on an unirrigable block of 100 acres at Kurundankulama 4 miles from Anuradhapura on the Trincomalee road. The object of the experiment was to determine (i.) the area of unirrigable land in the Dry zone which an average peasant family could farm *efficiently* using simple bullock drawn implements, (ii.) the income which a farm of that size would probably yield and, (iii.) whether the fertility of the soil could be maintained over long periods under the prevailing conditions of (*a*) intense rainfall during the comparatively short rainy season, (*b*) long spells of draught and (*c*) high temperatures. Incidentally it was attempted to ascertain whether with guidance and assistance the Wanni-villager could be trained successfully to substitute for his traditional chena cultivation of unirrigable land a system of rotational farming on established arable land in the Dry Zone.

SOIL AND CLIMATIC CONDITIONS AT KURUNDANKULAMA

The Dry Zone of Ceylon is roughly that portion of the Island where the annual rainfall is less than 70″ and where the greater part of this rainfall is received from October to December during the North-east monsoon. At Kurundankulama the annual rainfall is about 55″ of which about 30″ are received in October to December and about 10″ are received during mid March to mid April. During November the rainfall is so intense that the soil gets waterlogged unless adequate drainage is provided, but the soil gets very hard with a few days of dry weather. During the period May to August long spells of drought broken by occasional and irregular downpours are experienced. Usually about ten to twelve rainy days consisting of about five rainy spells are experienced during the period May 1st to August 31st. Appendix 1 gives the rainfall records for the period October 1940 to April 1948. These records indicate how irregular and unreliable the South-west rains are.

The soil which is representative of the major portion of unirrigable land in the North-Central Province is comparatively shallow and tends to get waterlogged during the monsoons, so that the control of run-off water while

at the same time preventing water logging is a big problem. The A horizon of the soil is 6″–8″ in depth and consists of a non-lateritic chocolate brown loam, compact and hard but friable. This layer of soil merges into a gravelly soil which ranges from a depth of about 8″ to about 6 feet. A compact pronounced gravelly layer about 8″–12″ thick exists at an average depth of about 2 feet. In places where soil wash has been severe, as on knolls, this gravelly layer has been exposed and lies on the surface. The layer of gravelly soil is followed by decomposing rock which is found at an average depth of about 6 feet from the surface. The soil is slightly alkaline in reaction with high exchangeable bases and appears to be derived, partly at any rate, from dolomitic limestone.

The topography is undulating. The higher areas tend to be gravelly while valleys and other low lying areas are rather heavy in texture and tend to get waterlogged badly during wet weather. These areas of impeded drainage are fairly extensive, covering about 20 per cent. of the total area.

The land was under medium jungle before it was reclaimed and made arable.

PROGRESS OF WORK

Ten families were selected in January, 1938, as prospective settlers. Although an original object of the scheme was that it should be worked by Wanni villagers, attempts made to secure 10 typical Wanni families proved abortive owing to the natural conservatism of the Wanni villager which made him reluctant to leave home. Eventually only one typically Wanni family was recruited. These prospective settlers had been earning a precarious livelihood as agricultural labourers on privately owned lands near Kurundankulama. It was soon found that six of the original ten settlers—the Wanni family was not one of these six—were misfits and after 18 months trial these six misfits were replaced in July, 1939, by peasants of a better type. Thereafter from time to time some of the selected men either abandoned their allotments or had to be expelled for bad work. To date 21 families have at various times worked these 10 allotments. Of the originally selected 10 families only 3 remain today, one of which is the Wanni family. Of the present settlers 3 have worked the scheme since its inception in 1938, 2 since July, 1939, 1 since April, 1940, 2 since June, 1941, and 1 since August, 1942. One of the allotments (No. 1) was abandoned in June 1945, by a settler who had worked it in an exemplary manner since October, 1940. Though there was a big demand for this allotment from relatives of the other settlers as well as from agricultural labourers in the vicinity a new settler was not selected for it ; instead, the arable section of this holding (which was well drained) was divided among three of the existing settlers whose arable areas were waterlogged, while the home garden was occupied by an overseer employed in the adjacent extension scheme which has just been completed. It is of interest to note here that the settler who abandoned his allotment in June, 1945, had accumulated a substantial cash reserve and that he took to trading at Kandy after abandoning his allotment. After a period of two years he begged for his allotment to be given back to him, but, this could not be done as it had already been divided among the three settlers whose lots had got watterlogged badly.

Development of the allotments was done in stages begining from January, 1938. An original feature of the scheme was that the settlers should devote part of their time to land reclamation operations such as jungle clearing, removal of stumps, &c. It was intended that progressive clearing and stumping not more than the capacity of the man and his family would be undertaken each year and that the family would be paid a subsistance allowance of about Rs. 15 per month until the whole of the allotment was brought into arable condition. It was soon evident that it was beyond the capacity of a settler struggling for his own existence to reclaim his holding with sufficient expedition. The Department therefore took on itself the task of developing the land by means of hired labour and creating established farms complete with the necessary live and dead stock. In this development work the settlers themselves took a part receiving wages for work done. This arrangement benefited them as they were able to supplement their income at a time when the earnings from the partially developed holdings were insufficient for their needs.

As blocks of land were made arable they were put under crops and the settlers were trained in the handling of implements and the care of livestock.

Development of the holdings was completed by September, 1943. Each completely developed holding consisted of the following :—

Ten acres of fully stumped unirrigable land which, except in the steeper portions, was soil conserved by bunds erected round the perimeter of each acre plot. On the steeper portions contour bunds were erected. (It was felt that contour bunds in the flater portions might cause waterlogging). Of these 10 acres the roadside acre in each allotment formed the home garden. It contained a wattle and daub house with cadjan roof. The house consisted of two rooms each measuring 12′ × 11′ and a verandah running right round the rooms. The back verandah was enclosed in part to form the kitchen. A detached pit latrine was also provided. The home garden also contained a cattle shed, a wire-netted poultry run complete with wire-netted poultry house, and a compost pit. It was planted up with 30 citrus trees, 8 mango trees, 12 coconut trees, a few miscellaneous trees (such as jak, breadfruit, pomegranate, sapodilla, &c.) and intercrops of plantains ; a small area was set apart for vegetable cultivation. Eight wells were sunk in the home gardens of lots Nos. 1, 2, 3, 4, 6, 7, 8 and 10. The well in lot 6 was meant to be shared by the settlers in lots 5 and 6 while the well in lot 8 was to be shared by the settlers in lots 8 and 9. The depths of the wells ranged from 27 feet to 40 feet.

The remaining nine acres in each allotment were designed to carry the following crops :—

Block A—6 acres 1st year Maha : Chilli
Yala : Pulse.
(*i.e.*, acre plots
Nos. 2-7) 2nd year Maha : Cereal (Kurakkan)
Yala : Gingelly
3rd year Maha : Cotton
Yala : Cotton (continued)

Block B—2 acres—1 acre Plantains—for 5 years
1 acre Napier Fodder grass for 5 years
(Acre plots Nos. 8 and 9)—(The fodder and plantations to be rotated once in 5 years in this block)
Block C—1 acre Permanent paddock (with a communal well sunk in
(acre plot No. 10) the 10th acre of allotment No. 5)

Each allotment has a road frontage of 210 feet and all 10 allotments are contiguous so that the home gardens, rotation areas, plantain areas, fodder areas and paddock areas form compact blocks. The paddock acres were barbed-wire fenced to form one communal grazing paddock 10 acres in extent with a common well sited in the 10th acre of lot No. 5.

The following livestock were provided to each settler :—

Two draught bulls (5 settlers received bulls of the Tamankaduwa breed while the other five received Hallekar bulls) ; one mismarked Scindi cow from a Government breeding farm ; one cow of local breed ; and one pen of poultry consisting of 1 R. I. R. Cockeral and 4 R. I. R. pullets.

Each settler received the following equipment also :—

One Ceres plough ; one Planet Junior intercultivator ; one blade harrow ; one seed drill ; three yokes ; one draught chain ; one axe ; one alavango ; one mamoty ; one mamoty fork ; one watering can ; one hand fork ; one rake ; one catty ; two buckets ; and one bee box.

The following were provided for communal use in addition to the well in the grazing paddock :—

Two Victory ploughs ; two disc harrows ; one Scindi stud bull ; two Jamnapari stud goats ; 20 she-goats ; a goat shed ; and one semi permanent store.

The expenditure in developing an allotment (during this period January, 1938–September, 1943) worked out on the average as follows (inclusive of war allowance) :—

	Rs.		Rs.
Clearing	300	Implements ..	180
Stumping	1,100	Planting material ..	100
Soil conservation ..	140	Miscellaneous (including overhead charges) ..	500
House	600		
Well	630		
Fencing	300	Total ..	4 100
Livestock	250		

Labour wages varied as follows during this period of Land development :—

	1938–1940.	1941.	1942.	1943.
	Rs. c.	Rs. c.	Rs. c.	Rs. c.
Rate per labourer ..	0 60 ..	0 75 ..	1 0 ..	1 20

The main items of land reclamation required the following units of labour (The land was under medium jungle) :—

Jungle clearing 30–40 labourers per acre.
Stumping and levelling 110–120 labourers per acre.
Soil conservation 10 labourers per acre.

From October, 1943 supervision of the settlers was relaxed to ascertain whether they could continue the cultivations successfully by themselves.

DISCUSSION OF RESULTS TO DATE

(1) *Soil Conservation System and Drainage.*—The topography of the land is such that a portion of lot 3, most of lots 4 and 5, and a portion of lot 6 form the bed of a valley with lots 7, 8 and 9 on one side and, lots 2 and 1 on the other side sloping into it. The bunds along the perimeters of each acre plot have not proved satisfactory. Run-off water from the higher-lying allotments has accumulated in the lower allotments (3, 4, 5 and 6) causing swamp conditions in these during the heavy rains. Owing to the presence of ancient water storage reservoirs in the vicinity of the scheme it has not been practicable to drain these lots adequately. Consequently the settlers in these lots have had repeated failures of their arable crops of chilli, kurakkan, cotton and gingelly (all of which cannot stand waterlogging) since Maha, 1943–44. It is significant that whereas lot No. 4, which is the most swampy, produced 10 bushels per acre of Kurakkan, 2 cwt. per acre of cotton and 15½ cwt. per acre of green chilli in 1942–43 it ceased to produce any of these crops since 1944–45 owing to waterlogging ; this indicates that the absorptive capacity of the soil in the higher lots had decreased materially after cultivation of the land had begun, thus increasing the flow of run off water into the lower lying lots, which are now fit for the cultivation of paddy only during the Maha seasons.

In future when the utilization of lands such as these is planned a soil conservation system of broad-based, graded bunds with a shallow drain on the upper side of the bund should be adopted on those portions which are higher and therefore easily drainable ; the drains should be made to lead the excess water in them through natural gullies (which should be protected suitably against further erosion) into the low lying areas of impeded drainage, where bunds should be narrow-based and on the contour, and the land between the bunds should be levelled. These low-lying blocks should be cropped in Maha with paddy which will benefit a great deal by the drainage water of the higher areas. The grade of the bunds on the higher areas should vary between 1 in 1,000 and 1 in 250 depending on the length of the bund. Where the bunds are not more than 1,000 feet long a uniform grade of 1 in 500 has proved effective. If the bund is longer than 1000 feet it should be divided into section of different grades, the section furthest away from the outlet into the gully having the least gradient, and the section nearest the outlet having the biggest gradient. Gravelly hillocks should be protected by broad-based bunds sited on the contour as there is no danger of waterlogging iu such areas. In practice it will be found that bunds should be 8–10 feet wide and about 10″–16″ in height, depending on the slope of the land. It will also be found that an average spacing of about 100 feet between bunds will be adequate provided

supplementary measures of soil conservation such as contour cultivation are adopted. The bund itself should be cultivated with crops. During the first year until the bunds get consolidated the cultivation of crops grown on these bunds will have to be done by means of hand hoes, as bullock drawn implements are liable to damage the bunds. Retardation of soil movement between bunds is of prime importance owing to the shallow nature of the soil. This can be achieved by contour cultivation. Six new allotments adjoining the old scheme have been developed incorporating the soil conservation system described in the preceding paragraph. These allotments have been worked by hired labour since Maha, 1945–46 and this soil conservation system has been found to work quite efficiently. Modifications in the soil conservation system on these lines were also effected in the settlement in Maha, 1946–47.

(2) *Training of Settlers, size of unit and Cropping Scheme.*—The six settlers situated favourably from the point of view of freedom from waterlogging have proved to be experts in the handling of bullock-drawn implements and the cultivation of the prescribed arable crops. Those provided with fast-working Hallekar bullocks have found it possible to grow arable crops efficiently on as much as 8 acres of land in a Maha season. (This was tested by allotting the more energetic settlers an additional block of cleared land adjoining their farms). Those provided with the relatively slower working Tamankaduwa bullocks, however, have found 6 acres to be the unit which they can cultivate efficiently with seasonal arable crops. Ploughing for the Maha crops commences with the first heavy shower in August–September. The chilli plots usually get two ploughings to reduce weeds growth to a minimum.

In considering the effect of cropping on soil fertility those allotments which were free from waterlogging only should be taken into account. If yields of crops secured immediately after the jungle was cleared are considered there has been an appreciable decline in fertility, but this is understandable as it is impracticable to maintain fully under cultivation the organic matter content of the soil as when it was under forest. Considering the yields from 1943–44 (in which year the settlers were placed in charge of the completely developed holdings) a decline in fertility is not apparent. There has been a big drop in the yield of cotton during the last 2 years but this can be explained by the unfavourable weather experienced and the relatively unattractive prices for seed cotton which made the settlers neglect this crop in order to devote more energy to Chilli which had a high market value. The yield of chilli in 1944–45 and in 1945–46 was higher than that obtained from the land soon after it was cleared. This appears to be due to the fact that the decline in soil fertility was compensated for by better cultural operations and planting to time as a result of the experience in regard to this crop gained by the settlers. It is fairly obvious that if these lands are to be farmed through long periods to come a scheme of resting the land under a grass fallow carrying livestock must be introduced. For this purpose the unit has been replanned as follows :—

1 acre home garden.
9 acres arable land of which 6 acres will be under *seasonal crops* and 3 acres under *pasture and fodder*.

The plantains in the arable area have proved a failure owing to the adverse effect of the long windy dry spell from May to September and therefore there has been no difficulty in persuading the settlers to allow this area to go under pasture. The cultivated block will carry substantially the same 3 year rotation of crops described earlier in this article, but the pasture and fodder block will be rotated with the cultivated block once in 6 years, and also *Gliricidia* will be established along block as well as holding-boundaries in order to obtain green manure for the cropped blocks. This scheme will mean that in a cycle of 18 years the land will be rested for 6 years under grass. Experience alone will show whether this length of rest is sufficient. Probably it may become necessary to enlarge the unit in order to provide a longer rest period under pasture during a cycle. It may be found, that after 6 years of cultivation under these crops the land must be rested for 6 years. In that case the extent of *arable* land will have to be 12 acres if local slow-working bulls are used, or 16 acres if fast-working bulls are used. Experience has indicated that from the farmers point of view a 2 acre home garden would be preferable to a 1 acre garden.

The yields per acre of the main crops secured from 1938–39 to 1946–47 by settlers No. 2, 8 and 9 who are favourably situated and who are good workers are given in Appendix II. It will be observed that these yields are appreciably less than those anticipated by Harbord in his article entitled "Rotational Farming Scheme, Kurundankulama, North-Central Province" in the *Tropical Agriculturist* Vol. XCVII. July, 1941.

Composting of farm wastes has not been done on the largest possible scale by the settlers who have yet to realise the value of doing this. Hitherto they have merely been collecting sweepings and weedings from the home garden, and cattle dung in a pit near the cattle shed. The manure thus accumulated is sufficient for only 2 of the 10 acres and this manure is always applied to the chilli which is the best cash crop. Occasionally the citrus has received a dressing of dung in the more progressive holdings. Cotton stalks are burnt in the field itself, while the kurakkan stubble is ploughed under. No fertilizers have been used to date.

(3) *Crops and Income.*—It has been found that chilli, cotton, all cereals except paddy, pulses and gingelly could be grown satisfactorily if the soil is well drained only.

The areas which get waterlogged in Maha can raise paddy only ; these areas must be bunded and levelled so as to impound all rain water, and it is preferable to lead all drainage water from higher areas into them in order to benefit the paddy crop. An average yield per acre of 15 bushels paddy over favourable and unfavourable seasons can be expected if these measures are adopted. In Yala these areas should be part under Sunnhemp and a Pulse.

Very gravelly areas are unsuitable for arable crops or pasture. Mango, if deep holing is done prior to planting, and cashew are permanent crops which will grow satisfactorily on these areas. Blocks which are not too gravelly can raise cotton, pulses and sunnhemp.

Though plantains failed as a purely unirrigated crop, satisfactory groves of plantains have been grown in home gardens near wells, and as inter-crops with an occasional watering during the dry weather.

Citrus can be grown well only if the soil is well drained and an occasional watering is given during droughts. In damp blocks or where watering was not done in the dry weather the citrus died back and was replaced by mango. Mango, coconut and other permanent crops have grown satisfactorily.

The main money crops are chilli, gingelly, plantains (from the home gardens) and cotton. So far chilli has furnished about 65 per cent. of the cash income. The following table shows the return from chilli in holdings 8 and 9.

Year.	Holding 8.		Holding 9.	
	Income from Chilli.	Total Income.	Income from Chilli.	Total Income.
	Rs.	Rs.	Rs.	Rs.
1941–42 ..	341	624	278	653
1942–43 ..	1,092	1,346	720	1,245
1943–44 ..	862	1,147	859	1,046
1944–45 ..	792	1,040	1,108	1,637
1945–46 ..	940	1,573	1,256	1,684
1946–47 ..	840	1,093	740	1,234
	4,867	6,823	4,961	7,499

Sales of livestock and livestock produce have not furnished more than 5 per cent. of the income so far, but stock bred on the holdings are now available for sale. The communal goat-rearing project failed as most of the goats died.

The income from 1943–44 to 1946–47 in respect of each settler and his bank balance at the end of April 1948, are given in Appendix IV. If only 4 allotments, which are free from waterlogging and which have been worked properly (*viz.* lots 2, 7, 8 and 9), are considered the average income per holding per year has worked out at Rs. 1,153 for the period 1943–1947. None of the settlers have purchased additional landed property but those whose holdings are not waterlogged have purchased accessories such as carts, furniture, bicycles, &c., and their standard of living is well above that of the average peasant not only of the Dry zone but even of the Wet zone. Some of them have had to meet heavy expenditure in respect of serious illnesses of relations in their villages. The health of all the settlers themselves and their families has been satisfactory. Hitherto agricultural produce has had a ready market and therefore the necessity for the settlers to organise a Co-oeprative Marketing Society has not been felt yet. The settlers have however organised a Co-operative Stores Society to purchase their requirements of textiles, rice, sugar, &c.

ECONOMICS

It appears that the State would be justified in aiding a scheme of dry farming in the extensive unirrigable tracts now under jungle in the Dry zone as a step towards solving the problem of self-sufficiency. The maintenance of fertility of the soil at a reasonable level over long periods appears possible and there is no difficulty in training peasants in this type of farming. In view of the variable nature of the soil it appears best to farm the land co-operatively in units of 6–10 families each. Otherwise those families having waterlogged or gravelly land will be at a disadvantage. A co-operative system on the other hand will enable each type of soil to be put to its proper and full use. *e.g.*, the low-lying lands with impeded drainage could be made to receive the drainage water of higher lying areas and put under a rotation :—

Paddy for Maha.

Green manure ($\frac{1}{2}$*) and pulse ($\frac{1}{2}$) for Yala.

Such a rotation besides utilizing the land would help considerably in the problem of self-sufficiency in rice considering that areas of impeded drainage form about 20 per cent. of the available land and the area of potentially irrigable land is limited. The only areas which should be demarcated and allotted separately to the families are the home garden blocks, where the more progressive families can find scope for their enterprise and initiative. It would be best to have a large unit of about 2 acres for the home garden for this purpose. A co-operative scheme of 6 families farming 84 acres of land has just been commenced on a block adjacent to the old settlement. The benefits of all the lessons learnt from the old settlement have been embodied in the planing of this new scheme. If the State establishes 100,000 families on farms like this the Island's annual production would be increased by the following :—

Cotton	400,000 cwt. ginned cotton
Chilli	600,000 cwt.
Paddy	3,000,000 bushels
Pulses	400,000 bushels
Livestock products :—	
	300,000 cwt. meat
	200,000,000 eggs
	50,000,000 gallons of milk
Fruits and vegetables	20,000,000 cwt.

Should the country be faced with the problem of unemployment and of paying a dole a scheme of State-aided dry farming could be a solution.

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(1.) Joachim, A. W. R. and Panditteseker, D. G.—" Studies on Ceylon Soils ". Tropical Agriculturist, Vol. LXXXVIII., page 71.

(2.) Harbord, G.—" Rotational Farming Scheme, Kurundankulama, North-Central Province ". Tropical Agriculturist, Vol. XCVII., page 22.

(3.) Editorial, Tropical Agriculturist, Vol. XCIX., page 1.

APPENDIX I

Rainfall Records at Kurundankulama from October 1940 to April, 1948

Months.	1940		1941		1942		1943		1944		1945		1946		1947		1948		Average per Month.	
	Rainfall, Inches.	Rainy Days No.	Rainfall, Inches.	Rainy Days, No.	Rainfall, Inches.	Rainy Days, No.	Rainfall, Inches.	Rainy Days, No.	Rainfall, Inches.	Rainy Days, No.	Rainfall, Inches.	Rainy Days, No.	Rainfall, Inches.	Rainy Days, No.	Rainfall, Inches.	Rainy Days, No.	Rainfall, Inches.	Rainy Days. No.	Rainfall Inches.	Rainy Days. No.
January ..	—	—	3·99	14	·73	4	7·54	4	5·91	7	0·32	3	1·19	4	7·06	7	2·12	6	3·61	6
February ..	—	—	1·48	8	·03	2	2·09	2	7·45	10	0·37	3	1·78	2	4·30	4	0·91	1	2·30	4
March ..	—	—	3·21	7	2·42	4	2·05	3	8·13	9	2·32	5	2·41	7	9·08	10	0·77	4	3·79	6
April ..	—	—	8·29	11	9·20	15	7·15	4	1·45	7	7·51	11	6·59	11	2·13	4	5·84	10	6·02	9
May ..	—	—	4·29	10	0·48	2	11·81	11	3·99	4	0·00	0	1·11	4	3·95	3	—	—	3·66	5
June ..	—	—	0·09	2	0·00	0	0·00	0	1·02	3	1·45	1	0·60	2	0·64	6	—	—	0·54	2
July ..	—	—	0·05	2	0·29	2	0·00	0	0·41	1	2·33	5	0·00	0	0·85	2	—	—	0·56	2
August ..	—	—	1·65	1	3·47	4	0·55	1	0·05	1	2·00	2	2·40	3	1·57	6	—	—	1·67	3
September ..	—	—	4·47	7	3·11	5	2·78	2	5·23	13	0·00	0	0·26	2	2·08	2	—	—	2·56	4
October ..	11·21	19	8·49	18	4·44	9	8·73	15	6·14	14	12·03	15	9·09	14	8·83	13	—	—	8·62	15
November ..	10·08	21	11·20	28	4·48	9	9·49	15	11·08	27	18·76	19	14·84	23	3·73	8	—	—	10·46	19
December ..	6·11	17	3·93	10	24·68	21	11·07	20	5·67	11	5·90	6	21·29	22	9·85	13	—	—	11·06	15
Total for year ..			51·14	118	53·33	77	63·26	77	56·53	107	52·90	70	61·56	94	54·07	78			56·12	89

APPENDIX II

Yields of Seasonal Crops obtained by the three best Settlers at Kurundankulama

Year.	Crop No.	Cotton. lb.	Chillie (green weight) lb.	Kurakkan Bushels.	Gingelly Bushels.
1938–39	2	502	224	6	—
	8	586	560	—	—
	9	464	896	—	—
1939–40	2	546	504	6	5½
	8	506	—	5½	15½
	9	656	1,344	5½	13 2/5
1940–41	2	360	921	10	8½
	8	136½	1,038	11 1/5	10 3/5
	9	362	1,214	12⅓	15 3/5
1941–42	2	776	1,921	5	⅓
	8	591	758½	5⅓	1 3/5
	9	730	1,023	5⅜	2 1/5
1942–43	2	149	2,106	11 3/7	4½
	8	293	2,077½	11¼	2 1/5
	9	228	1,055	4½	3 2/5
1943–44	2	155	574	8	—*
	8	326	2,232	5½	1
	9	329	1,244	6 3/5	2½
1944–45	2	126	1,344	4	5
	8	294	2,240	2	2
	9	286	1,680	7½	2
1945–46	2	140	2,072	5	10
	8	378	2,016	3	5
	9	224	1,700	5	6
1946–47	2	—*	—*	3	1 5/8
	8	42	1,400	1½	4½
	9	112	1,232	3	4½

* Crop failed completely due to waterlogging.

APPENDIX III

Gross Income from the Kurundankulama Holdings during Period, September, 1943 to September, 1947 and Savings Bank Balance at end of April, 1948

Settler No.	Maha, 1943–44 and Yala, 1944.	Maha, 1944–45 and Yala, 1945.	Maha, 1945–46 and Yala, 1946.	Maha, 1946–47 and Yala, 1947.	Total per Settler for Period.	Bank Balance at end of April, 1948.
1	864	983	Vacant (arable block left fallow)	—	1,847*	—
2	1,057	900	1,695	708	4,360	1,068 78
3	650	530	1,115	396	2,691	38 0
4	304	455	200†	658‡	1,617	38 20
5	615	518	615	372	2,120	36 42
6	660	997	1,101	457	3,215	5 15
7	1,249	825	920	642	3,636	1 60
8	1,147	1,040	1,573	1,093	4,853	217 96
9	1,046	1,637	1,684	1,234	5,601	203 28
10	716	464	185§	766§	2,131	0 37
Total	8,308	8,349	9,088	6,326	32,071	

* Income for 2 years only.

† Income from home garden only. All arable crops failed due to waterlogging.

‡ This includes Rs. 437 realised from the sale of chilli grown in 2 acres of vacant Lot No. 1.

§ Only partial cultivation of holding was done as allottee lost the use of one of his bulls through an injury.

COCONUT SHELLS

BY

DR. R. CHILD
DIRECTOR, COCONUT RESEARCH SCHEME, CEYLON

Reprinted from the Magazine of the King's College (London) Chemical Society.

CEYLON contains over a million acres of coconut palms, which are estimated to produce annually about 1,800 million coconuts. Roughly half this number go to provide the domestic requirements of the population, whilst the remainder are exported mainly as copra, coconut oil and desiccated coconut. Incidentally to these industries arise considerable quantities of coconut shells; 1,800 million whole shells weigh about 300,000 tons and it seems reasonable to ask what happens to this annual quantity and to consider possibilities for its better economic utilization.

COMPOSITION

Qualitatively coconut shells are similar in composition to the hard woods, though the lignin content is higher and the cellulose content lower. The following are typical figures:—

Moisture	..	8·0 per cent.	"Methoxyl" content	5·6	per cent.
Ash ..	..	0·6 ,,	Nitrogen ..	0·11	,,
Solvent extractives	..	4·2 ,,			
Lignin ..	..	29·4 ,,			
Pentosans	..	27·7 ,,			
Uronic anhydrides	..	3·5 ,,			
Cellulose	..	26·6 ,,			
		100·0 ,,			

USE AS FUEL

In coconut growing countries like Ceylon, coconut shells are commonly used as domestic fuel; laundries, bakeries and the like use fair quantities. But copra drying accounts in Ceylon for most of the utilization as fuel. In the usual type of drier, the wet coconut meat containing about 45 per cent. of moisture is dried down to copra of 6 or 7 per cent. moisture content by the direct heat from burning rows of coconut shells.

For this purpose dry shells freed from adhering fibres have the advantage that they produce a clear-burning fire with little smoke. A plantation will, using the old type of kiln, use about two-thirds of its shells for copra drying.

The increasing utilization of shells for industrial purposes and the premium obtainable for "hot air dried" as against "smoke-dried" copra, has led to the introductions of Patent kilns which use any available fuel such as the usual debris on coconut plantations of fallen fronds, bunch stalks, old logs, &c.

CHARCOAL

In the years immediately preceding World War II., Coconut Shell Charcoal was in demand for the preparation of gas—adsorbent carbons ; during the years 1937–1940 inclusive nearly 60,000 tons of coconut shell charcoal were exported from Ceylon to the value of about £300,000. About 20,000 whole shells are required to make a ton of charcoal.

The charcoal exported was the crude material, made by the time-honoured process of burning in pits with exclusion of air. Since 1939, in Ceylon, however, the kiln distillation of shells has been carried out both on a laboratory and industrial scale.

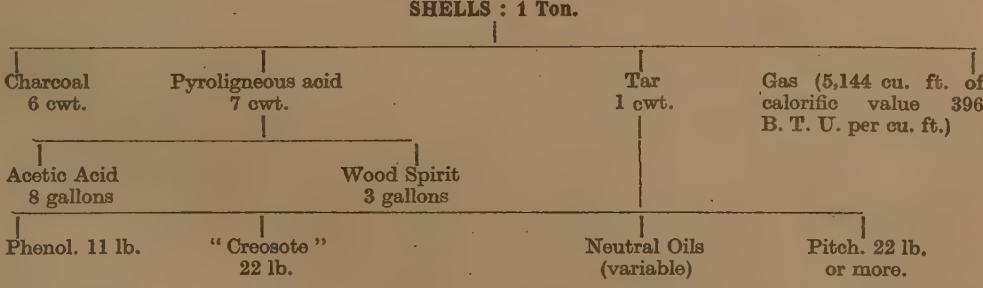
DISTILLATION PRODUCTS

Although shells are of a similar chemical nature to wood, there are certain industries based on wood as a raw material which cannot make use of shells. Thus, paper pulp cannot be produced from shells as the cellulose of the latter is non-fibrous.

One group of industrial products is derived from the distillation of wood viz., acetic acid, wood spirit and creosote ; and here from the technical point of view, coconut shells have some advantages over wood.

When shells are burned in ordinary pits for charcoal they yield rather less than one third of their weight of charcoal. If, instead, they are fired in ovens or retorts heated from the outside, and the vapours condensed, there can be obtained from 100 lb. of shells, besides the charcoal (about 30 lb.), some 35 to 40 lb. of pyroligneous acid and about 5 lb. of settled tar. The acetic acid content of the pyroligneous acid is remarkably high—much higher than that from most woods—and usually runs over 10 per cent.; about 2·5 to 3 per cent., of wood spirit is also recoverable.

The following table shows the approximate quantities of primary products obtainable by dry distilling one ton of shells :—


SHELLS : 1 Ton.
Charcoal 6 cwt.
Pyroligneous acid 7 cwt.
Tar 1 cwt.
Gas (5,144 cu. ft. of calorific value 396 B. T. U. per cu. ft.)
Acetic Acid 8 gallons
Wood Spirit 3 gallons
Phenol. 11 lb.
" Creosote " 22 lb.
Neutral Oils (variable)
Pitch. 22 lb. or more.

It is a remarkable feature that the tar, when distilled up to 280°C, leaves only about 25 per cent. of pitch ; and the phenols constitute over 30 per cent. of the total. The higher boiling phenols (given in the table as " Creosote ") have not been fully investigated ; they seem (unlike beech-wood tar) to contain little or no guaiacol.

The rubber industry in Ceylon uses about 300 tons of acetic acid every year for latex coagulation. Consequently the Government during the war erected a plant for the production of acetic acid. It was not possible to develop by-products owing to the difficulty of obtaining plant—there was however some recovery of wood naphtha, which was used for the production of french polish and varnish ; the tar was simply distilled and the water-free distillate supplied as a wood-preservative ; whilst there was some demand for the pitch from boat-builders.

With further applied research, the prospects for post war development of an industry based on the distillation of coconut shells seem good.

OTHER APPLICATIONS

The pentosans of coconut shell are largely xylosans and good yields of *xylose* can be obtained by dilute acid hydrolysis. The use of concentrated acids leads to *furfural;* this substance has industrial applications but there are cheaper sources such as waste oat-hulls, corn cobs, &c. By alkaline oxidation a mixture of vanillin and syringaldehyde is obtained; this observation at present has no obvious commercial application, but throws light on the interesting chemistry of the lignin of coconut shells. The lignin seems to differ somewhat from most wood lignins,—at least there are considerable differences in the distillation products —and investigation will probably be of interest in the elucidation of the general chemistry of lignin.

USES OF SHELLS AS SUCH

Shells—or strictly speaking, half shells (the half without the eyes)—are used in their natural form in Ceylon and other coconut growing countries for drinking bowls, rubber latex collecting cups and the like. Various carved articles, often very attractive, are made by local craftsmen.

COCONUT SHELL FLOUR

Finely ground coconut shell has become a commercial product, used as a filler in plastics. It gives a smooth and lustrous finish to moulded articles, and improves resistance to moisture and heat.

Lastly it may be of interest to refer to another " use " of finely ground shells. In 1900 it was reported in America that powdered coconut shell was commonly used to adulterate spices. Such adulteration has not been recently reported; in any case it is not difficult to detect either chemically or microscopically.

SUMMARY

Small numbers of half shells are used as latex cups, drinking vessels and in similar ways; the bulk of shells produced in Ceylon in pre-war days was, however, used as fuel, both domestically and otherwise. In the immediate pre-war years, notable quantities were used for making charcoal; during the war this was extended to the production of acetic acid. Since the war, ground coconut shell is being exported and is utilised as a filler for plastics. Other post-war developments are expected to be the fuller investigation and utilization of the products of distillation.

Cognate laboratory studies are likely to give also results of theoretical interest, especially in lignin chemistry.

Memoranda on Colonial Fertilizer Experiments by A. B. Stewart and E. M. Crowther. Colonial No. 214, H. M. Stationary Office, London, 1947. Price Sixpence. Pp. 27.

Experiments on the effects of manures and of artificials in the tropics have been many. The results are generally rather similar and vary mainly quantitatively, with the possible exception of potash whose behaviour in tropical soils is erratic. Broadly speaking, a position has been reached when for the common commercial fertilizers and the usual bulky organics a reasonably dependable answer can be given to the question of how much response is likely to follow a dressing of ordinary amount. The older experiments, even those before the era of randomisation, yielded a lot of dependable results which subsequent trials by more refined methods have done little to alter. There is, however, a very serious gap in knowledge of long-term trends in tropical countries and only too often a failure to appreciate residual effects, particularly of phosphates which may be remarkably sustained. Interactions in the tropics do not always follow the same course as under cooler conditions nor do tropical crops all respond similarly. The relations between tropical rotations and manurial practices are still very

imperfectly known and such complexities as the responses of transplanted rice with separate manuring in nursery and field have been little studied. There is ample work to be done but the advances which can be made will not come so easily as 30 years ago nor can they be obtained by such simple techniques. The issue of this short publication should be useful in drawing attention to the advantages of more thorough design of experiments and to some of the problems which have been little studied in the past.

The advantages of the newer designs of experiments are well set out and the Appendix on confounding is a neat summary of this tricky business. We would enter a plea for more long-term experiments and for greater study of residual effects, both of which we think will repay study. The role of minor elements is also awaiting attack though in this case difficulties of equipment and refined methods of analysis are a handicap in many tropical countries. Workers in tropical lands often have to contend with difficulties which are spared to those in more developed places and are therefore reluctant to adopt some of the more complex designs. Raids by elephants or porcupines can play havoc with a neat factorial arrangement, and the burden of trying to apply a missing-plot analysis is often not attractive. The hazards of complex experiments using unfamiliar labour often not very dependable, is a further deterrant while the cost per unit of information gained is sometimes much lower with complex designs than with more simple ones. Despite such disadvantages the use of factorial lay-outs is becoming increasingly necessary if advances are to be made beyond what has already been achieved in most tropical countries by simpler methods.

We commend this Memorandum to all those engaged in manurial trials, and we heartily endorse Dr. Crowther's dislike of those imaginary entities P_2O_5 and K^2O. Very often it is overlooked that a conventional dressing such as 40 lb. N, P_2O_5 or K_2O per acre means applications of 40 lb. of N, 17½ lb. of P and 33 lb. of K.

D. R.

Rubber in Textile Factories by Colin Macbeth, M.I.A.E., F.I.R.I., pp. 135. Illustrated London. The British Rubber Development Board, Market Buildings, Mark Lane, E.C. 3. 1948, Gratis.

The uses of rubber in industry are numerous and expanding and in many of the uses to which it is put in one industry it is equally applicable in others. It is for this reason that those interested in the general aspects of the engineering applications of rubber should not neglect to read this publication because of the specialisation implicit in its title.

Almost exactly half of the book deals with the transmission of power by belt from power house to line-shaft, from line-shaft to machines and from individual motors to machines, and it gives useful hints on belt installations, belt jointing and repairing. The construction and application of all kinds of rubberised belts, both flat and " vee ", and their variants are amply described and illustrated and there is information here of value to engineers whether connected with the textile industry or not and whether at home or abroad.

Other chapters devoted to the uses of rubber in bleaching, printing, dyeing and finishing contain useful facts about rubber joints, rubber rollers, bearings, pumps, rubber-metal bonded units and hydro-extractors which any chemical engineer will welcome. A chapter on garments and utensils is an acceptable one to the works chemist responsible for the safe handling of corrosive liquids.

All engineers should have a copy of this publication if for no other reason than that it demonstrates so clearly that rubber must not only not be overlooked as an engineering material, but it can also provide unique means of solving awkward problems of design and installation.

E. R.

COCONUT RESEARCH SCHEME (CEYLON)—BOARD OF MANAGEMENT

MINUTES OF THE NINETY-FIRST MEETING OF THE BOARD OF MANAGEMENT, COCONUT RESEARCH SCHEME, HELD AT 2.30 P.M. ON MONDAY, JANUARY 26, 1948, IN THE BOARD ROOM OF THE TEA PROPAGANDA BOARD, PRINCE BUILDINGS, COLOMBO.

Present.—Mr. D. Rhind (Director of Agriculture), Chairman ; Mr. T. D. Perera, C.C.S. (Deputy Secretary to the Treasury) ; Senator C. A. M. de Silva (Chairman, L. C. P. A.) ; Mr. Vernon Rajapakse (Representing the L. C. P. A.) ; Mr. C. E. L. de Silva (Representing the L. C. P. A.) ; Mr. A. Pearson (Representing the P. A. of Ceylon) ; Mr. G. Panditteseker a, J.P., U.M. (Representing the Small-holders) ; Mr. D. D. Karunaratne, J.P., M.P. (Representing the Small-holders) ; Dr. R. Child (Director) ; Mr. S. C. Kahawita (Secretary).

Apology for absence was received from Mr. E. Muttukumaru.

(1) MINUTES

(*a*) The Minutes of the previous meeting held on December 1, 1947, which had been circulated were confirmed.

(*b*) On the proposal of Senator C. A. M. de Silva, the Board decided that if no amendments to Minutes are sent to the Secretary within two weeks of their circulation, they shall be considered approved.

(2) CORRESPONDENCE

(*a*) Letter from Mr. L. J. de S. Seneviratne, C.C.S., the former Chairman, in acknowledgment of the vote of appreciation passed at the 90th meeting was tabled.

(*b*) The Director informed the Board that he had been invited by the Council of Scientific and Industrial Research, India, to contribute an article on coconut to the New Dictionary of Economic Products and Industrial Resources of India.

(3) BOARD OF MANAGEMENT

(*a*) The Chairman on bahalf of the Board welcomed Mr. T. D. Perera, C.C.S., Deputy Secretary to the Treasury, as a member of the Board.

(*b*) Regarding the nomination of two Representatives to the Board from Parliament the Chairman reported that the Secretary to the Ministry of Agriculture and Lands has informed him on January 10, 1948, that one of the persons from whom enquiry has been made whether he would be willing to serve as a member has not yet replied and his attention has been invited.

(4) STAFF

(*c*) *Technical Assistant to the Botanist.*—The Director reported that he was unable to recommend the appointment of any of the applicants for this post. He had discussed with the Botanist the work of his Division, and Dr. Raghavan had agreed that the post might be retrenched, provided that an extra field assistant were appointed. The Board agreed to this.

(5) SUB-COMMITTEES

The Minutes of the 5th meeting of the Estates Sub-Committee which had been circulated was tabled and approved.

(6) **FINANCE**

One day's Pay to Labourers.—The Board sanctioned a days full pay leave to all checkroll labourers on the estates on February 4, 1948, in view of the independence celebrations.

(8) **ANY OTHER BUSINESS**

The Board decided to hold its next meeting on February 21, 1948, in Colombo.

The meeting terminated at 4.20 P.M. with a vote of thanks to the Chair and to the Tea Propaganda Board for the tea and the use of the Board Room.

By order,

S. C. KAHAWITA,
Secretary, Coconut Research Scheme.

MINUTES OF THE THIRTEENTH MEETING OF THE PADDY ADVISORY BOARD

The Thirteenth meeting of the Paddy AdvisoryBoard was held at the Maha-Iluppallama Agricultural Station at 10.30 A.M. on Monday, September 29, 1947.

Prior to the meeting a demonstration of agricultural machinery in ploughing, disc harrowing, manure spreading, seed drilling and threshing was conducted.

Dr. A. W. R. Joachim, Deputy Director of Agriculture, presided. The following members were present :—Rev. Fr. L. W. Wickremasingha, Messrs. A. M. Clement Dias, R. H. de Mel, W. P. A. Cooke, A. Arulambalam, K. J. Gunawardene (Secretary), Dissawe P. B. Bulankulama, M.P., intimated his inability to attend the meeting.

The Chairman stated that the members would be glad to hear of the election of two of its members to the Ceylon Parliament. The Board thereon adopted the following resolution " That this Board congratulates Dissawe P. B. Bulankulama and Gate Mudaliyar M. S. Kariappar on their being elected to Parliament and also on their appointment as Parliamentary Secretaries and wish them every success in their work ". The Chairman also welcomed Mr. W. P. A. Cooke as a member of the Paddy Advisory Board.

CONFIRMATION OF MINUTES

The Minutes of the 12th meeting of the Paddy Advisory Board were confirmed.

ACTION TAKEN ON PREVIOUS RESOLUTIONS

Wild Pigs.—Re the resolution on the destruction of wild pigs which do much damage to paddy cultivation in the Eastern Province, the C. D. A. M. stated that he was taking steps to organize the sale of pork from Batticaloa. Mr. de Mel said that the Board should request the attention of the Minister for Agriculture and Lands, to the fact that the reply dealt with only one aspect of the resolution in question. If the Commissioner for Devolopment of Agricultural Marketing could not sell the pork the alternative was for the Minister for Agriculture and Lands to authorize the Government Agent, Eastern Province, to pay a bounty of Rs. 2 plus 2 cartridges to every person who produced the tail of a wild pig.

Wild Paddy.—Re the resolution on the spread of wild paddy in the Eastern Province, the Chairman stated that trials were being conducted in the Northern Province, where the infestation was more localized to ascertain ways and means of evolving suitable methods for the eradication of the weed. It may be possible to adopt any measures which may be found successful in the Northern Province in Eastern Province too. Mr. Cooke pointed out that the best method of eradicating wild paddy was to prepare the fields as for sowing paddy. On germination the plants should be uprooted and paddy plants from a nursery prepared before hand should then be transplanted. In this manner the farmers need not loose one season's crop.

Silting and De-silting of Tanks.—Re the resolution on silting and de-silting of tanks in the Hambantota District it was decided to refer the resolution back to the Director of Irrigation for further information as to the cause of the reduction in the capacity of these tanks during the last few years.

Stipulation of Paddy Cultivation and Modification of Internal Purchase Scheme.—It was felt that the Board would be most greatful if early consideration could be given to the following recommendations already forwarded to the Minister for Agriculture and Lands.

(1) That it is most desirable that a clear statement of the policy of Government regarding the price to be paid for paddy in the near future should be issued at an early date.

(2) That the organization of the I. P. S. in its present form is unnecessarily expensive and that it can now be modified.

(3) That the contributions of individual cultivators may now be assessed on the basis of their contributions to the I. P. S. since its inception.

(4) That the money saved by modifying the I. P. S. should be utilized for paying a bonus for every bushel of paddy contributed by cultivators in excess of the assessed quantity to be surrendered.

Resolutions.—The following resolution moved by Mr. A. M. Clement Dias and seconded by Mr. R. H. de Mel was adopted :—

> " That Government should separately collect and store all paddy suitable for seed for tracts that were affected by floods during Yala 1947, so as to avoid a shortage of seed paddy which is otherwise bound to occur in Yala 1948 ".

Date for next Meeting.—It was decided to hold the next meeting of the Board on or about January 15, 1948 in Colombo. The Board expressed their grateful thanks to the D. A. O., F.M.M.I. and A. E. for having got up the very useful demonstration of agricultural machinery.

The meeting terminated at 12.30 P.M. with a vote of thanks to the Chair.

K. J. GUNAWARDENE,
Secretary, Paddy Advisory Board.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED JANUARY 31, 1948

Province	Disease	Fresh Cases during the month	Cases up to date since Jan. 1, 1948	From Jan. 1, 1948 to Jan 31, 1948			
				Deaths	Recoveries	Balance Ill	No. shot.
Western Province	Foot-and-mouth	1	1	—	1	—	—
Colombo Municipality	Foot-and-mouth	14	14	—	—	14	—
	Rabies	11	11	—	—	—	11
Colombo Quarantine Station	Anthrax	7	7	7	—	—	—
Northern Province	Black Quarter	9	9	9	—	—	—
	Rabies	1	1	—	—	—	1
Southern Province	Foot-and-mouth	525	525	15	—	510	—
Central Province	Rabies	2	2	—	—	—	2

Peradeniya, February 26, 1948.

T. M. Z. MAHAMOOTH,
Deputy Director (Animal Husbandry), and
Government Veterinary Surgeon.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED FEBRUARY 29, 1948

Province	Disease	Fresh Cases during the month	Cases up to date since Jan. 1, 1948	From Jan. 1, 1948 to Feb. 29, 1948			
				Deaths	Recoveries	Balance Ill	No. shot
Western Province	Foot-and-mouth	—	1	—	1	—	—
	Rabies	1	1	1	—	—	—
Colombo Municipality	Foot-and-mouth	118	132	—	81	51	—
	Rabies	5	16	—	—	—	16
Colombo Quarantine Station	Anthrax	—	7	7	—	—	—
Northern Province	Black Quarter	—	9	9	—	—	—
	Rabies	—	1	—	—	—	1
North-Central Province	Foot-and-mouth	206	206	6	200	—	—
North-Western Province	Mange in goats	16	16	—	15	1	—
Southern Province	Foot-and-mouth	140	665	24	350	291	—
Central Province	Rabies	—	2	—	—	—	2
	Piroplasmosis	1	1	—	1	—	—

T. M. Z. MAHAMOOTH,
Deputy Director (Animal Husbandry), and
Government Veterinary Surgeon.

Peradeniya, March 24, 1948.

3—J. N. A 80309 (5/48)

ANIMAL DISEASE RETURN FOR THE MONTH ENDED MARCH 31, 1948

Province	Disease	Fresh Cases during the month	Cases up to date since Jan. 1, 1948	From Jan. 1, 1948 to Mar. 31, 1948.			
				Deaths	Recoveries	Balance Ill	No. shot.
Western Province	Foot-and-mouth	7	8	—	8	—	—
	Rabies	—	1	1	—	—	—
Colombo Municipality	Foot-and-mouth	146	278	—	260	18	—
	Rabies	10	26	—	—	—	26
Colombo Cattle Quarantine Station	Anthrax	—	7	7	—	—	—
Northern Province	Black Quarter	—	9	9	—	—	—
	Rabies	—	1	—	—	—	1
North-Central Province	Foot-and-mouth	48	254	6	216	—	32
North-Western Province	Mange in goats	—	16	—	16	—	—
Southern Province	Foot-and-mouth	71	736	24	697	15	—
Central Province	Rabies	—	2	—	—	—	2
	Piroplasmosis	—	1	—	1	—	—
Uva Province	Foot-and-mouth	24	24	—	8	16	—
	Rabies	1	1	—	—	—	1

T. M. Z. MAHAMOOTH,
Deputy Director (Animal Husbandry), and
Government Veterinary Surgeon.

Peradeniya, April 28, 1948.

METEOROLOGICAL REPORT, JANUARY, 1948

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Minimum)		Amount	No. of Rainy Days	Offset
	°	°	°	°	%	%		Ins.		Ins.
Agalawatta	89·5	+1·4	70·7	+0·1	82	97	6·4	7·21	13	—0·07
Anuradhapura	84·9	+1·6	70·3	+1·1	81	95	6·6	3·47	9	+2·33
Badulla	77·1	+0·7	65·1	+1·5	84	95	6·8	5·37	19	—4·95
Batticaloa	82·2	+0·7	74·2	+0·7	84	93	6·7	12·38	17	—0·50
Colombo	87·6	+1·2	72·6	+0·8	76	90	5·4	4·52	13	+0·56
Diyatalawa	72·2	+0·2	59·6	+2·2	85	94	6·0	3·76	16	—2·88
Galle	84·9	+1·0	73·8	+0·9	84	90	5·0	10·31	11	+6·43
Hakgala	66·4	—0.7	53·5	+2·2	82	94	6·8	5·56	14	—6·87
Hambantota	85·8	+0·8	74·0	+1·4	78	88	7·8	1·97	7	—2·03
Jaffna	83·1	+0·1	73·5	+1·5	80	90	4·8	4·87	11	+0·46
Kandy	85·2	+1·6	68·5	+1·5	74	90	4·7	2·68	8	—3·66
Kurunegala	88·4	+1·9	70·5	+0·7	73	93	5·0	3·01	7	—2·10
Lunuwila	90·2	+2·6	72·7	+1·8	72	93	4·6	1·13	8	—2·46
Mannar	83·9	+0·5	75·4	+1·3	78	86	5·5	7·02	14	+3·18
Nuwara Eliya	67·6	—0·3	48·1	+1·6	80	90	7·1	3·34	12	—3·62
Puttalam	85·6	+0·1	69·1	—0·8	76	95	5·2	3·33	10	—0·10
Ratnapura	89·2	—0·2	71·7	+0·6	69	95	5·2	9·52	11	+3·26
Talawakele	74·7	+0·4	56·8	+1·5	73	85	5·3	4·06	9	+0·19
Trincomalee	81·0	+0·4	76·0	+0·9	84	86	6·5	4·61	22	—3·70

Rainfall in January was below normal over the greater part of the Island. Larger deficits of the order of 5 to 10 inches, or more occurred on the north-eastern slopes of the hills, while elsewhere in the north-east quarter the shortfalls ranged chiefly from 2 to 5 inches. The largest deficits were 19·63 inches at Hendon Estate, 18·62 inches at Upper St. Martin's Estate and 13·35 inches at Lower St. Martin's Estate.

Excesses were found along the east coast to south of Batticaloa, in the extreme north-west, and scattered in places in the southern and south-western low-country. The largest excesses were 8·98 inches at Ratmalana, 7·61 inches at Manalputty Aar and 7·32 inches at Kadukkamunai.

Heaviest rain was experienced on the north-eastern slopes of the hills, and ir a small area on the east coast to south of Batticaloa. In these regions the monthly totals exceeded 15 inches, the highest being 21·42 inches at Upper St. Martin's Estate, 20·94 inches at Lower St. Martin's Estate, 20·37 inches at Hendon Estate (all in the Nitre Cave District), 20.87 inches at Kadukkamunai and 20·61 inches at Manalputty Aar. Large totals to south of Batticaloa were chiefly due to the unusually heavy rains in this region on the 2nd, several stations recording amounts over 8 inches.

In the north and in the south-west the rainfall generally ranged from 2 to 5, or 5 to 10 inches. Least rain was recorded in parts of North-Western and Sabaragamuwa Provinces where the monthly totals were below 2 inches.

There were 23 daily falls of 5 inches or over in January, nearly all of them occurring on the 2nd in the neighbourhood of Batticaloa. The highest were 10·72 inches at Kadukkamunai, 10·00 inches at Thumpenkeni and 9·90 inches at Manalputty Aar.

Temperatures were above average. The highest recorded shade temperatures were 93·9° at Ratnapura on the 22nd and 93·8° at Lunuwila on the 18th, while the lowest air temperature was 36·6° at Nuwara Eliya on the 27th. Humidities were generally above average. Winds were north-easterly.

D. T. E. DASSANAYAKE,
Superintendent, Observatory.

METEOROLOGICAL REPORT, FEBRUARY, 1948

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Minimum)		Amount	No. of Rainy Days	Offset
	°	°	°	°	%	%		Ins.		Ins.
Agalawatta	90·3	+0·4	70·7	—0·4	79	97	5·3	5·65	11	+ 0·16
Anuradhapura	89·4	+2·5	68·2	—1·5	71	92	4·2	0·12	5	— 1·60
Badulla	80·6	+1·6	61·7	—1·6	74	94	3·8	0·57	3	— 2·60
Batticaloa	84·1	+1·2	73·7	—0·2	78	90	4·7	0·28	3	— 3·93
Colombo	87·6	+0·4	72·5	+0·3	76	93	4·4	0·17	2	— 2·43
Diyatalawa	76·3	+1·6	56·0	—0·9	68	85	3·0	0·47	1	— 1·90
Galle	87·2	+1·9	73·6	—0·1	81	90	4·2	1·29	5	— 2·00
Hakgala	70·7	+0·6	52·6	+1·5	75	78	4·1	1·18	4	— 2·89
Hambantota	86·5	+0·5	73·0	—0·1	79	88	6·2	0	0	— 1·46
Jaffna	86·3	+0·7	73·2	+0·8	74	88	1·5	0	0	— 1·46
Kandy	89·1	+2·5	66·1	—1·0	64	84	3·0	0·04	2	— 2·27
Kurunegala	92·6	+2·6	69.4	—0·4	64	93	2·8	0·21	4	— 1·78
Lunuwila	91·4	+1·5	71·6	+0·1	72	95	3·3	0·93	2	— 0·61
Mannar	87·0	+0·7	73·9	+0·1	72	88	2·6	0	0	— 1·70
Nuwara Eliya	69·7	+0·1	43·3	—1·7	74	85	5·0	0·24	2	— 1·75
Puttalam	90·2	+1·8	70·9	+0·5	66	93	2·8	0·20	2	— 1·17
Ratnapura	91·8	+0·2	70·8	—0·6	70	95	2·9	11·82	10	+ 6·52
Talawakele	78·2	+1·8	53·2	—1·5	62	78	5·0	0	0	— 1·97
Trincomalee	83·9	+1·4	75·9	+0·1	76	84	4·0	0·11	2	— 2·54

There was very little rain over the Island in February, the majority of stations receiving less than an inch for the whole month. Stations which recorded over 2 inches were found chiefly in the south-west quarter, areas around Ratnapura and Udugama getting over 5 inches. The largest monthly aggregates were 11·82 inches at Ratnapura, 11·28 inches at Gonapenigala Estate and 8·98 inches at Millawa. The lowest totals occurred in the north of the Island, where a number of stations recorded no rain at all.

Rainfall was below average almost throughout the Island. The deficits were, however, not large, as February is normally a dry month. The larger deficits, of the order of 5 to 10 inches, occurred on the north-eastern slopes of the hills, *e.g.* 9·93 inches at Hendon Estate, 8·80 inches at Upper St. Martin's Estate and 7·73 inches at Lower St. Martin's Estate. Small excesses were found in limited areas in the neighbourhood of Ratnapura and Udugama, the highest being 6.52 inches at Ratnapura, 5·37 inches at Gonapenigala Estate and 3·27 inches at Baddegama Estate.

The only daily fall recorded over five inches was 5·15 inches at Baddegama Estate on the 14th.

Temperatures were above average by day, and generally about average by night. The highest recorded shade temperature was 97·2° at Lunuwila on the 25th, while the lowest air temperature was 37·5° at Nuwara Eliya on the 6th. Winds were north-easterly.

Hailstorms were reported from Maliboda and Ratnapura on the 13th, and from Anuradhapura on the 17th.

D. T. E. DASSANAYAKE,
Superintendent, Observatory.

METEOROLOGICAL REPORT, MARCH, 1948

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Minimum)		Amount	No. of Rainy Days	Offset
	°	°	°	°	%	%		Ins.		Ins.
Agalawatta	90·5	+0·6	71·4	—0·7	77	98	5·7	11·52	17	+ 1·39
Anuradhapura	94·2	+3·2	69·6	—2·0	66	93	3·1	0·38	5	— 3·77
Badulla	83·6	+1·3	63·7	—0·6	72	91	4·4	1·94	5	— 3·11
Batticaloa	85·6	+0·3	74·8	—0·2	79	90	7·7	2·63	7	— 0·84
Colombo	89·2	+1·3	73·7	—0·3	75	90	4·6	2·63	7	— 2·03
Diyatalawa	79·0	+1·9	57·9	—0·3	67	85	3·5	3·77	7	— 1·12
Galle	87·8	+1·5	74·5	—0·6	82	90	4·8	0·80	7	— 4·51
Hakgala	73·2	+0·2	52·1	+0·1	68	81	4·4	5·22	6	— 1·10
Hambantota	87·6	+0·8	74·4	+0·2	78	88	6·4	0·11	4	— 3·28
Jaffna	89·0	+0·5	75·2	—0·6	70	86	2·2	0·01	1	— 1·57
Kandy	91·9	+3·4	69·3	+0·8	62	85	3·8	4·14	9	— 1·70
Kurunegala	96·5	+3·9	71·6	—0·4	60	90	4·2	9·77	7	+ 3·49
Lunuwila	90·6	+0·8	73·1	—0·3	75	93	3·6	11·12	10	+ 5·81
Mannar	89·9	+0·6	75·1	0	70	88	3·6	0·31	3	— 1·53
Nuwara Eliya	71·5	+0.7	46·4	+0·1	66	79	5·8	4·04	8	— 0·05
Puttalam	92·5	+2·8	72·2	—0·7	72	93	3·2	0·65	4	— 2·43
Ratnapura	92·9	+1·2	71·9	—0·7	74	85	4·6	10·15	19	— 0·23
Talawakele	79·6	+1·9	55·3	—0·1	62	76	4·6	4·58	13	— 0·04
Trincomalee	86·1	+0·8	76·5	+0·2	77	86	4·8	0·43	4	— 1·87

In March too rainfall was below normal over a large portion of the Island. The larger deficits (of the order of 2 to 5 inches) occurred in the north-central parts, on the eastern slopes of the hills, and in limited areas in the south and south-west. The largest deficits were 6·28 inches at Meeriabedda Estate, 6·25 inches at Lemas Estate and 5·74 inches at Vincit Estate. Excesses were found chiefly in the Province of Sabaragamuwa and to the north of it, the largest being 9·17 inches at Alagalla, 8·80 inches at Polgahawela, 7·71 inches at Kegalla and 7·00 inches at Kempitikande Estate.

Heaviest rain (mostly above 10 inches) occurred in the Province of Sabaragamuwa, the highest being 19·20 inches at Keragala Estate, 18·51 inches at Eraminigolla, 17·71 inches at Beralapanatara school and 17·48 inches at Millawa. Rainfall was generally below two inches in the northern third of the Island and along the south-east coast. Several stations in the north received no rain at all.

There was considerably heavy rain in the neighbourhood of Kurunegala on the 29th and 30th, several stations recording falls over 5 inches. The highest were 7·02 inches at Kurunegala P. W. D. on the 29th and 6.53 inches at Kosgolla on the 30th.

Temperatures were above average by day, and slightly below average by night. The highest recorded shade temperature was 100·3° at Kurunegala on the 20th, while the lowest air temperature was 35·1° at Nuwara Eliya on the 19th.

Winds were variable.

Hailstorms were reported from Doragalla Estate, Pussellawa, on the 6th, from Hettipola on the 7th, and from Mandara Nuwara Estate, Kandapola on the 31st.

D. T. E. DASSANAYAKE,
Superintendent, Observatory.

A List of New Acquisitions to the Library in the Period November 1, 1947 to February 29, 1948 :—

Books.

1. Atlas of Avian Anatomy—by Chamberlain, F.W. (Issued to Specialist in Animal Husbandry (P)).
2. The Cultivation of Viruses and Rickettsiæ in the Chick Embryo—by Beveridge and Burnet (Issued to D. D. V.)
3. Chemical Composition of Plants as an Index of their Nutritional Status—by Goodall and Gregory.
4. The A. B. C. and X. Y. Z. of Bee Culture—by Root and Root.
5. Tropical and Sub-Tropical Fruits—by Dahlgren, B.E.
6. Rural America—by Robertson, A.
7. Management of Dairy Plants—by Mortensen.
8. The Soils that Support Us—by Kellogg, C. E.
9. Soil Mechanics—by Krynine, D. P.
10. Practical Animal Husbandry (5th Edition)—by Miller and Robertson (Issued to Specialist in Animal Husbandry (P)).
11. The Structure and Reproduction of the Algæ, Volume II—by Fritsch.
12. Chambers' Technical Dictionary—by Tweney and Hughes.
13. The Universities Year Book, 1947.
14. United States Department of Agriculture Year book 1943–47.
15. The Dominion Experimental Farms—by Canada Department of Agriculture.
16. Rudiments of Riding—by Hitchcock (Issued to Principal, Veterinary College).
17. A Manual of Rabbitry—by Wilson (Issued to Principal, Veterinary College).
18. Ducks and Geese and How to Keep them—by Chatterton (Issued to Principal, Veterinary College).
19. Handling Horses—by Stewart (Issued to Principal, Veterinary College).
20. Medical Photography—by Longmore (Issued to Principal, Veterinary College).
21. How to Study Birds—by Stuart Smith (Issued to Principal, Veterinary College).
22. Rabbit Farming—by Goodchild (Issued to Principal, Veterinary College).
23. A Practical Course in Agricultural Chemistry—by Knowles and Watkin (Issued to Principal, Veterinary College).
24. Practical Goat Keeping—by Abbey (Issued to Principal, Veterinary College).
25. All About British Animals—by Gaskell (Issued to Principal, Veterinary College).
26. Why Tuberculosis Exists—by Lovell, R. G. (Issued to Principal, Veterinary College).
27. Diseases of the Pig and Its Husbandry—by Anthony (Issued to Principal, Veterinary College).
28. Animals are my Hobby—by Lintz (Issued to Principal, Veterinary College).
29. Training and Horse Management in India—by Hayes (Issued to Principal, Veterinary College).
30. Rural New Market—by Lyle (Issued to Principal, Veterinary College).
31. The Book of the Horse—by Fitzgerald (Issued to Principal, Veterinary College).
32. Livestock Improvement—by Nicholls (Issued to Specialist in Animal Husbandry (P)).
33. Annual Report of the Smithsonian Institution, 1946.
34. British Construction Equipment.
35. Milk and Milk Products (Latest Edition)—by Eckles, Combs and Macy.
36. Foundations of Plant Geography—by Cain.
37. Field Crops—by Rather.
38. Principles of Dairying (3rd Edition)—by Judkins and Mack.
39. The Nature and Properties of Soils—by Lyon and Buckman.
40. Plant Physiology—by Thomas, M.
41. Phenothiazine in Veterinary Medicine—by Edwards, J. T.
42. Baird and Tatlock Catalogue of Standard Chemical and Biological Apparatus, 1947.

Journals.

1. Agricultura Veterinaria.
2. The Agricultural Situation.
3. All India Cattle Show Prospectus, 1948.
4. American Fruit Grower.
5. Atlas Hall.
6. Australasian Herbarium News.
7. Barbados Department of Agriculture—Bulletins.
8. Brazil Ministry of Agriculture, S. D. A.
9. Brazil Ministry of Agriculture, S. I. A.
10. British Guiana Department of Agriculture—Economic Intelligence Series.
11. Bulletin Semestrial de l' office National Anti-Acridien.
12. Cahiers Coloniaux.
13. Canada Department of Agriculture—Annual Reports.
14. Canada Department of Agriculture—Reports of the Veterinary Director-General.
15. Chicago Natural History Museum—Popular Series.
16. Colonial Products Research Council Annual Reports.
17. Council for Scientific and Industrial Research, Australia,—Reprints.
18. Cusec.
19. Department of Scientific and Industrial Research Bulletins.
20. Edinburgh and East of Scotland College of Agriculture Farmers' Leaflets.
21. Edinburgh and East of Scotland College of Agriculture Miscellaneous Publications.
22. Engineering and Allied Trades Review.

23. The Feed Situation.
24. Florida University Abstracts of Theses.
25. Gardeners' Chronicle of America.
26. Heredity.
27. Herts Experimental and Research Station Annual Reports.
28. Imperial Bureau of Animal Health—Veterinary Bulletins.
29. Informe Del Comisionado de Agriculturay Comercio.
30. Iowa Report on Agricultural Research.
31. Iowa State College Farm Science Reports.
32. Iowa State College Agricultural Experiment Station—Youth Series.
33. Ithaca Gentes Herbarum.
34. Jamaica Department of Agriculture Bulletins—New Series.
35. Jamaica Annual Report of the Government Chemist.
36. Journal of Agricultural Research Reprints.
37. Kentucky Agricultural Experiment Station Circulars.
38. La Cana de Azucar en Cuba.
39. The Revue Agricole de Ille de la Reunion.
40. Madras Government Museum Natural History Section Bulletin (New Series).
41. Mauritius Sugar Cane Research Station Bulletins.
42. Memoirs de l' office National Anti-Acridien.
43. Memoiria De, Obras Publicas.
44. Montreal University Institute of Botany Contributions.
45. National Institute of Agricultural Botany—Journal.
46. North Carolina State College Agricultural Extension Service.
47. Office International Des Epizooties Statistiques.
48. Ontario Department of Agriculture Horticultural Experiment Station Reports.
49. Ontario Department of Agriculture Statistics Branch Annual Report—Senate.
50. Parliamentary Debates—Senate (Ceylon) (Hansard).
51. Parliamentary Debates—House of Representatives (Ceylon) (Hansard).
52. Parliamentary Series, 1947–48 (House of Representatives, Ceylon).
53. Phillipine Journal of Animal Industry.
54. The Poultry and Egg Situation.
55. Publications De L' Institut National Pour L' Etude Agronomique Du Congo Belge, Bruxelles.
56. Rehovat Agricultural Research Station Bulletins.
57. Revista Del Instituto de Defenia Del Cafe De Costa Rica.
58. Revue Agricole de I'lle de la Reunion.
59. Revue Pedagogique L' E' Cole at la famille.
60. Rubber Industry Report.
61. Society of Chemical Industry Journal Reprints.
62. The Spice Mill.
63. Taiwan Agricultural Research Institute Technical Bulletins.
64. Unasylva.
65. United Empire.
66. United States Department of Agriculture—Miscellaneous Circulars.
67. United States Department of Agriculture—Review of Patents Relating to Pest Control.
68. United States Department of Commerce—Foreign Commerce Weekly.
69. United States Information Service—Bombay—March of Science.
70. U. S. A.